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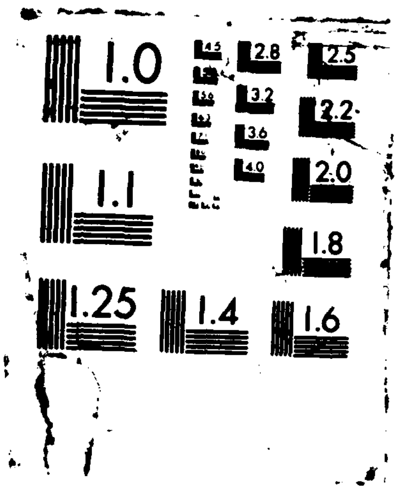
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IREPS 3.0 User's Manual

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This report introduces the reader to a variety of effects that the lower atmosphere (troposphere) has on the performance of many naval electromagnetic systems and describes the use of the Integrated Refractive Effects Prediction System (IREPS).

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1. INTRODUCTION

1.1 PURPOSE

The purpose of this manual is to introduce the reader to a variety of effects that the lower atmosphere (troposphere) has on the performance of many naval electromagnetic (EM) systems and to describe the use of the Integrated-Refractive-Effects Prediction System (IREPS) Revision 3.0. The effects of concern here are only significant at EM frequencies above 100 megahertz (MHz) and, therefore, capable of affecting radar, ultrahigh frequency (uhf) and microwave communications, electronic warfare, and missile guidance systems. The effects that the ionosphere has on high frequency (hf) communications, or other systems, are specifically not included in this document.

1.2 THE IREPS CONCEPT

IREPS has been developed, and is continuing to be refined at NOSC, to give a shipboard environmental-data processing and display capability for comprehensive refractive-effects assessment upon naval surveillance, communications, electronic warfare, and weapons guidance systems. IREPS has been successfully used under operational conditions aboard most CV/CVNs to assess and exploit refractive effects in tactical situations.

Prior to describing the products and operation of IREPS Revision 3.0, a background discussion of refractive effects, their causes, and resulting benefits or detriments to naval EM systems will be presented.

2. BACKGROUND

2.1 WHAT ARE REFRACTIVE EFFECTS?

The term "refractive effects" refers to the property of a medium (here, the lower atmosphere) to refract, or bend, an EM wave as it passes through the medium. In this document, the term is taken to imply a wider meaning which includes all propagation effects of, or related to, the lower atmosphere that affect the performance of EM systems. As such, the term includes not only refraction and ducting, but also reflection from the sea surface, multipath interference, diffraction around the earth's surface, tropospheric scattering, sea clutter, and many other propagation mechanisms or processes. For most naval EM systems, the occurrence of ducting in the troposphere provides the most dramatic impact on system performance.

2.1.1 Ducting and Refraction

The term "ducting," as used in this document, means the concentration of radio (or radar) waves in the lowest part of the troposphere in regions characterized by rapid vertical changes in air temperature and/or humidity. Such atmospheric ducts are analogous to the ducts encountered in ocean acoustic propagation resulting from vertical changes in seawater pressure, temperature, and salinity. "Surface" ducting means a concentration of radar waves immediately adjacent to the sea surface. To understand these concepts, a knowledge of the bending, or refraction, of radar waves in the atmosphere will be required.

The refractive index, n, of a parcel of air is defined as the ratio of the velocity of propagation of an EM (e.g., radar) wave in a vacuum to that in the air. Since EM waves travel slightly slower in air than in a vacuum, the refractive index is slightly greater than unity. At the earth's surface, the numeric value of the refractive index n is usually between 1.000250 and 1.000400. To have a number that is easier to handle, the refractivity, N, has been defined to be

$$N = (n - 1)\, 10^6, \tag{1}$$

such that surface values of refractivity N vary between 250 and 400. Refractivity can be expressed as a function of atmospheric pressure, temperature, and humidity by the relation

$$N = \frac{77.6P}{T} + \frac{3.75 \times 10^5 e}{T^2}, \tag{2}$$

where

P is atmospheric pressure in millibars,
T is temperature in degrees Kelvin, and
e is water vapor pressure in millibars.

For a well-mixed "standard" atmosphere, both temperature and humidity decrease with altitude such that N decreases with height at a rate of about 39 N units per 1000 meters (or 12 N units per 1000 feet). The behavior of an EM wave propagating horizontal to the earth's surface is such that it will bend or "refract" toward the region of higher refractivity (lower velocity). For the standard atmosphere, a radar wave will bend down toward the earth's surface, but with a curvature less than the earth's, as illustrated in figure 2-1. If, however, the air temperature increases with altitude or the humidity decreases abnormally fast with altitude, then N will decrease with height much faster than normal. If N decreases faster than 157 N units per 1000 meters (48 N units per 1000 feet), then a radar wave will refract downward with a curvature exceeding the earth's curvature and a surface duct will be formed, as illustrated by figure 2-2. Note that, while the radar wave refracts toward the sea surface, it reflects, or "bounces", upward from the sea in this example. It is the continuous refracting down and reflecting up that forms the surface duct and allows for surface detections far beyond the normal horizon.

As a convenience in determining the occurrence of ducting, the modified refractivity M has been developed. M is related to N by

$$M = N + 0.157\ h \text{ for altitude } h \text{ in meters, or}$$
$$M = N + 0.048\ h \text{ for altitude } h \text{ in feet.} \qquad (3)$$

The modified refractivity takes into account the curvature of the earth in such a way that the presence of ducting can be determined from a simple inspection of M plotted versus height. Whenever M decreases with height, a so-called "trapping" layer is formed, in which an EM wave can be refracted toward the earth's surface, thus forming a duct. Figure 2-3 shows N and M plotted versus height for a standard atmosphere, and figure 2-4 shows N and M plotted versus height for one type of surface ducting condition, illustrating the concept.

In figure 2-3, M constantly increases with height; hence, there is no trapping layer or resulting duct formation. In figure 2-4, M decreases with height; thus a trapping layer is formed. If the M value at the top of the trapping layer is less than the M value at the surface, then a surface-based duct will be formed in the height interval indicated by the dashed vertical line in figure 2-4. If the M value at the top of the trapping layer is greater than the M value at the surface, then a so-called "elevated" duct will be formed as illustrated in figure 2-5.

Besides trapping, there are three other terms that describe the vertical gradient (or change with height) of N and M, namely superrefractive, standard, and subrefractive. Superrefractive implies an N-gradient that is stronger than the normally expected or standard gradient, but not strong enough to form trapping. Subrefractive implies an N-gradient weaker than the standard radient, which results in less refraction or bending than normal. Figure 2-6 shows the relative amounts of bending for each of the four types of refraction. Table 1 shows the definition of these four types of refraction in terms of the N and M gradients.

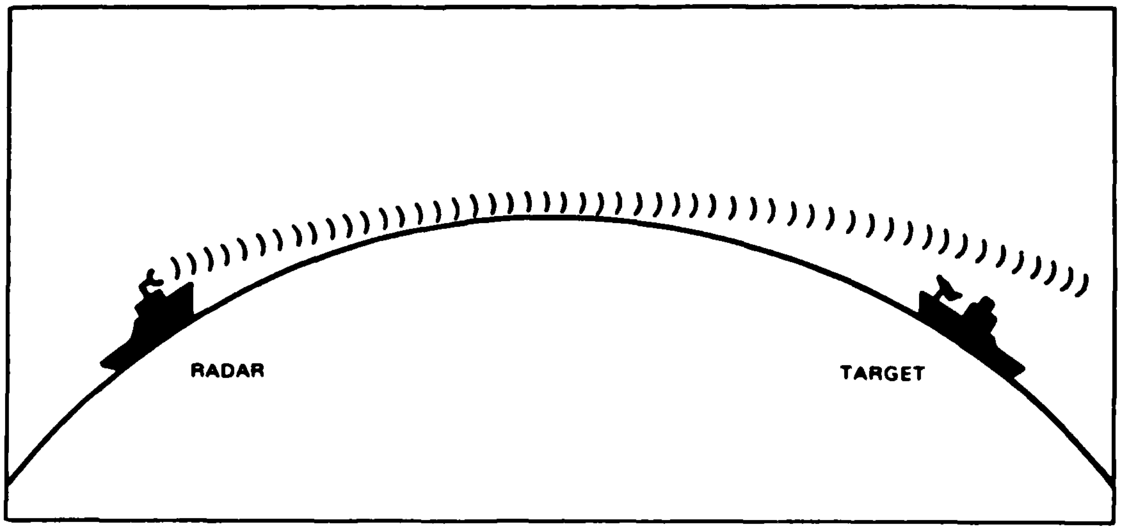


Figure 2-1. Radar wave path under standard atmospheric conditions. Note that the path curves downward but at a rate less than the earth's curvature. Beyond-the-horizon target detection is not possible.

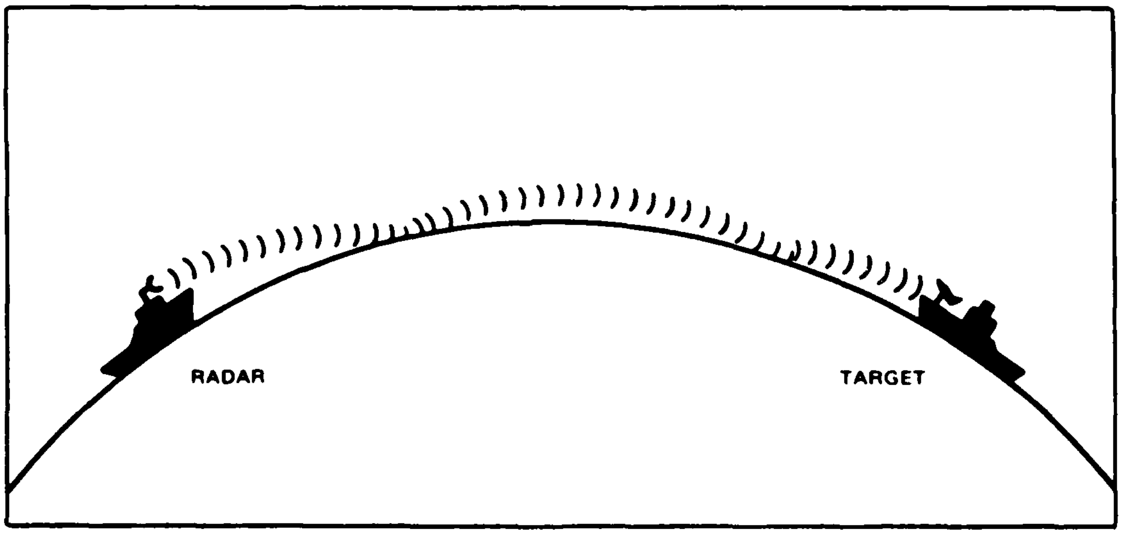


Figure 2-2. Radar wave path under ducting conditons. Note that the path curves downward at a rate exceeding the earth's curvature,resulting in beyond-the-horizon target detection.

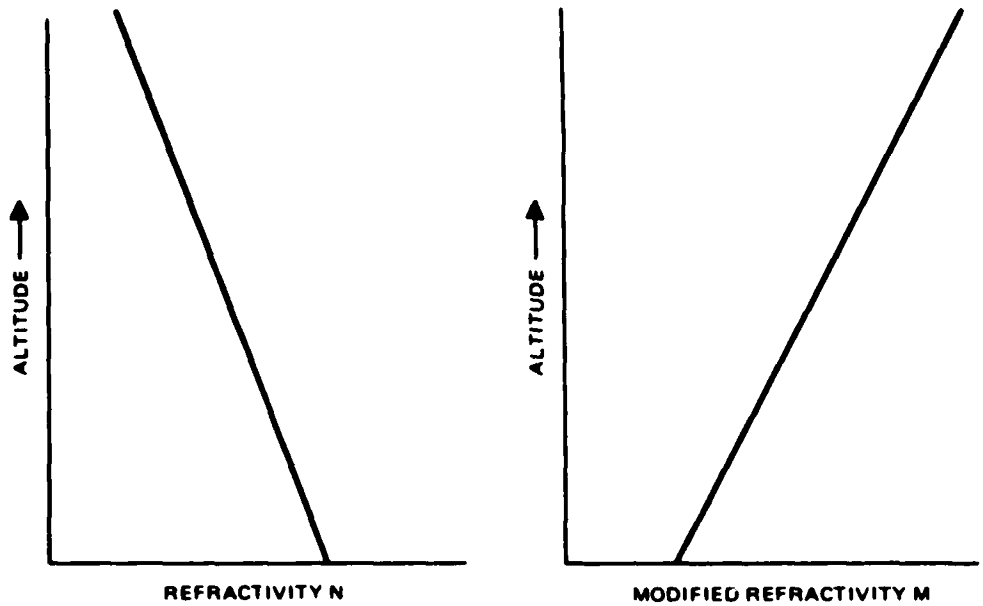


Figure 2-3. Refractivity N and modified refractivity M versus altitude for a standard atmosphere.

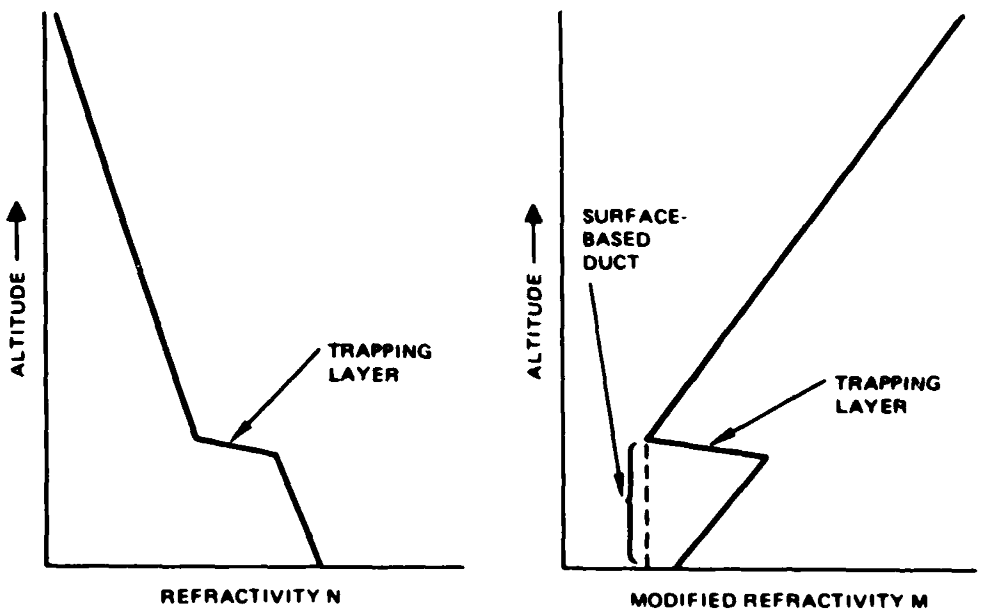


Figure 2-4. Refractivity N and modified refractivity M versus altitude for a surface-based duct created by an elevated trapping layer.

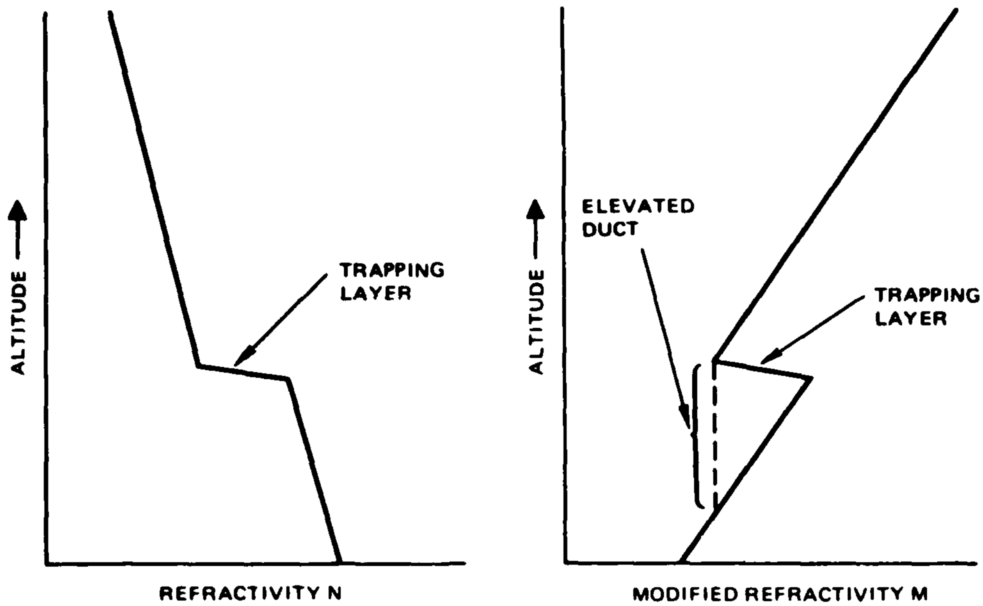


Figure 2-5. Refractivity N and modified refractivity M versus altitude for an elevated duct created by an elevated trapping layer.

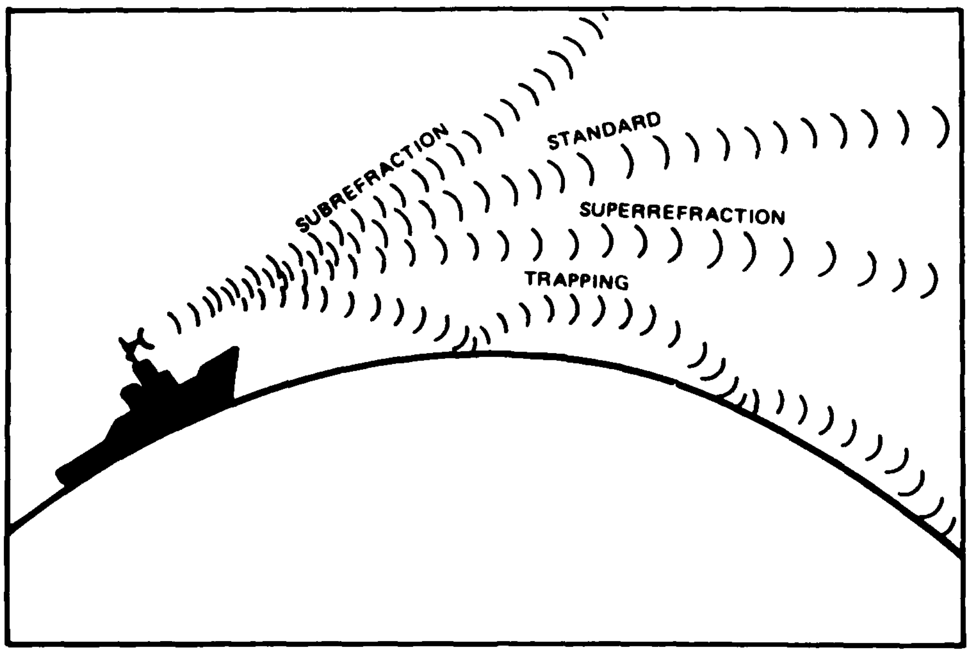


Figure 2-6. Relative bending for the four types of refraction.

Table 2-1. Relation of N- and M- gradients.

	N-Gradient	M-Gradient
Trapping	≤ -157 N/km ≤ -48 N/kft	≤0 M/km ≤0 M/kft
Superrefractive	-157 to -79 N/km -48 to -24 N/kft	0 to 79 M/km 0 to 24 M/kft
Standard	-79 to 0 N/km -24 to 0 N/kft	79 to 157 M/km 24 to 48 M/kft
Subrefractive	>0 N/km >0 N/kft	>157 M/km >48 M/kft

2.1.2 Types of Ducts

Three distinct types of ducts are of concern to naval EM systems, and each must be treated separately. These three types are the following: (1) surface-based ducts formed from elevated layers; (2) elevated ducts; and (3) evaporation ducts. Surface-based ducts formed from elevated refractive layers generally give extended detection, intercept, and communication ranges for all frequencies above 100 MHz, provided both the transmitter and receiver (or radar and target) are near, or within the duct. Such surface-based ducts are nearly always less than 1 kilometer (3000 feet) thick, although thicknesses of up to 300 meters (1000 feet) are more common. Elevated ducts primarily affect air-to-air surveillance, communication, electronic warfare, or weapons guidance systems. For instance, detection ranges of air targets by airborne early-warning radars can be greatly extended if both the radar and target are within the elevated duct. However, at the same time, radar "holes" or blind spots can occur for radars or targets above the duct. Elevated ducts occur at altitudes of near 0 to 6 kilometers (20,000 feet), although maximum altitudes of 3 kilometers (10,000 feet) are far more common. The evaporation duct is created by the very rapid decrease of moisture at the air/sea interface and, although variable in its strength, most frequently extends ranges for surface-to-surface systems operating above 3 GHz. Each of these three types of ducts will be discussed in more detail in later sections of this document; but first, an introduction to standard (non-ducting) propagation mechanisms will be presented.

2.2 STANDARD PROPAGATION MECHANISMS

Standard propagation mechanisms are those propagation mechanisms and processes that are, in effect, independent of the existing refractivity conditions. Although standard propagation mechanisms are often described in terms of a standard refractivity profile that has a linear decrease of refractivity of about 12 N units per thousand feet, the mechanisms are generally present for all refractivity conditions even though they may be dominated by the various types of ducting.

2.2.1 Path Loss and Free-Space Propagation

If an EM wave is propagating from a transmitter to a receiver (or target), and both the transmitter and receiver are sufficiently far removed from the earth or other objects, the EM wave is said to be propagating in free space. The path loss (or propagation loss) between the transmitter and receiver, in decibels, is defined to be

$$\text{Loss} = 10 \log_{10} \frac{Pt}{Pr}, \tag{4}$$

where Pt is the power transmitted and Pr is the power received.

In free space, the path loss is determined by the geometrical spreading of the power over the surface of the expanding sphere centered at the transmitter and is given in decibels as

$$\text{Loss}_{fs} = 37.8 + 20 \log_{10} (f) + 20 \log_{10} (R), \tag{5}$$

where f is the transmitter frequency in MHz and R is the range between the transmitter and receiver in nautical miles. Equation 5 assumes that both the transmitter and receiver employ lossless isotropic (radiating uniformly in all directions) antennas. This free-space loss would be a good approximation for path loss between two aircraft if both aircraft were at reasonably high altitudes and there were no elevated ducts present near their altitudes. However, for a transmitter or receiver near the earth's surface, reflections from the surface must be taken into account.

2.2.2 Reflection and the Interference Region

When an EM wave strikes a nearly smooth large surface, such as the ocean, a portion of the energy is reflected from the surface and continues propagating along a path that makes an angle with the surface equal to that of the incident ray, as illustrated by figure 2-7.

The strength of the reflected wave is determined by the reflection coefficient, which depends upon the frequency and polarization of radiation, the angle of incidence, and the roughness of the reflecting surface disturbed by the wind. Not only is the magnitude of reflected wave reduced, but the phase of the EM wave is also altered. Typical values for the reflection coefficient for shallow incidence angles and smooth seas are 0.99 (i.e., the reflected wave is 99 percent as strong as the incidence wave) and 180 degrees of phase change.

As the wind speed increases, the ocean surface grows rougher and the reflection coefficient can decrease to about 0.15 (the phase change remaining unaffected). For a transmitter near the surface, the reflection process results in two paths to a receiver (or target) within line of sight, as illustrated by figure 2-8.

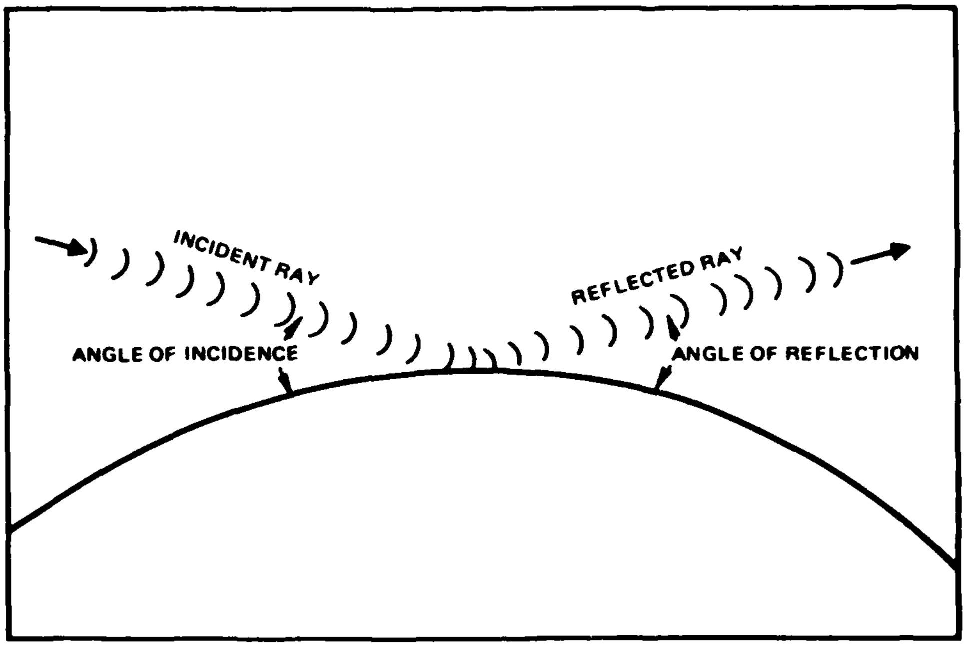


Figure 2-7. Incident ray and reflected ray illustrating equal angles of reflection.

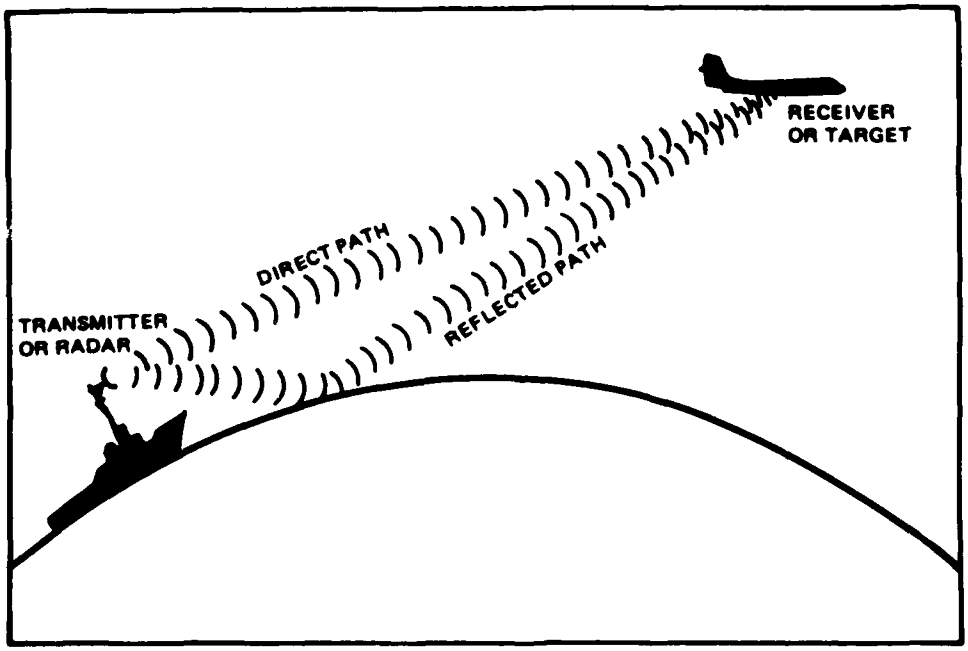


Figure 2-8. Surface-to-air geometry illustrating direct and sea-reflected paths.

As the geometry changes in figure 2-8, the relative lengths of the direct path and reflected path also change, which results in the direct and reflected wave arriving at the receiver in varying amounts of phase difference. The received signal strength, which is the vector sum of the signal strengths of the direct and reflected wave, causes the received power to vary up to 6 decibels above and up to 20 decibels below the free-space value.

Figure 2-9 shows a plot of path loss versus range for a 5000-MHz (5 GHz) transmitter located 60 feet above the sea surface and a receiver at 100 feet above the sea surface for standard refractive conditions. The region in which the path loss is dominated by the interference of the direct and sea-reflected wave is called the interference region and is labeled as such in figure 2-9. The free-space path loss, as calculated from equation 5, is included in figure 2-9 for reference and illustrates how the path loss oscillates above and below the free-space value in the interference region. The depth of the nulls depends very much on the surface roughness related to the wind speed. The example here is for a smooth sea surface associated with zero wind speed, but as the wind speed increases, the path loss in the nulls would approach the free-space value.

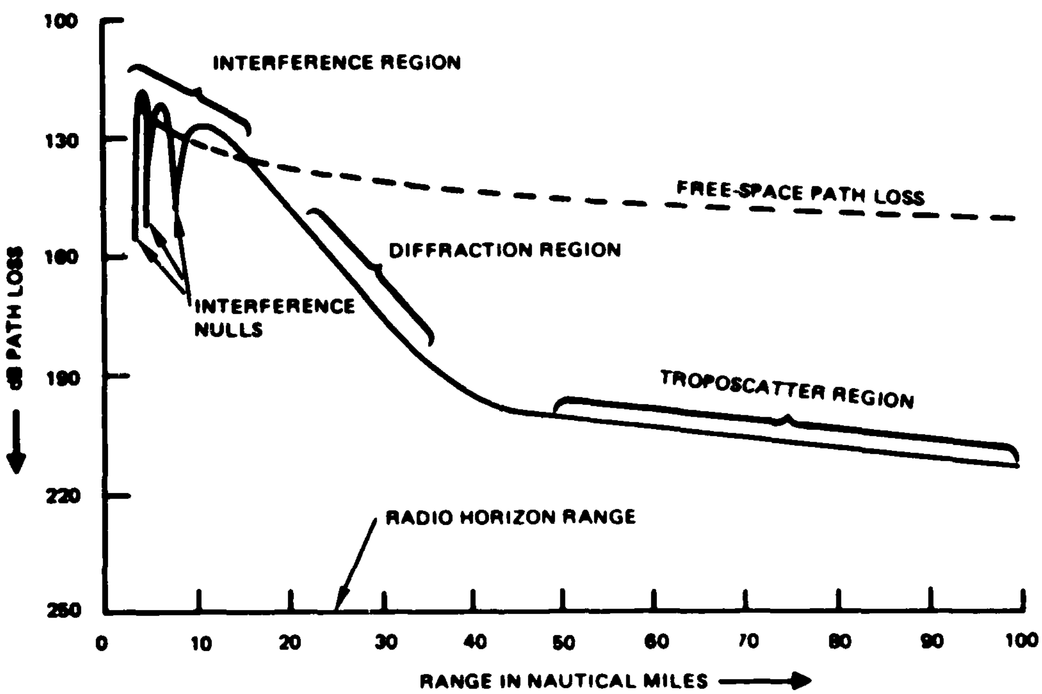


Figure 2-9. Path-loss curve for a 5000-MHz transmitter at 60 ft and a receiver at 100 ft for a standard atmosphere.

2.2.3 Diffraction

Near the radio horizon range, where the path between the transmitter and receiver is just tangent to the earth's surface, the path loss is dominated by diffraction around the earth. The diffraction region, which is sometimes called the shadow region, is characterized by propagation beyond the line-of-sight radio horizon because of the ability of a radio wave to travel along an interface of dissimilar materials, in this case the earth's surface and the atmosphere. The amount of power, or signal strength, available to a receiver in this region is very dependent on the refractive conditions near the earth's surface. In fact, the various forms of ducting to be described in the following sections are actually special cases of propagation in the diffraction region. To calculate path loss in the diffraction region is, in many cases, very complicated and is usually based on notions of normal-mode propagation and atmospheric waveguide considerations.

2.2.4 Tropospheric Scatter

At ranges far beyond the horizon, the path loss is dominated by a mechanism called tropospheric scatter or troposcatter (figure 2-9). Propagation in the troposcatter region is the result of scattering of the EM wave from refractive heterogeneities at relatively high altitudes that are in line of sight to both the transmitter and receiver. The calculation of path loss in the troposcatter region is quite easily performed by using semiempirical formulations. The rate at which the path loss increases with range, within the troposcatter region, is considerably less than the rate in the diffraction region (figure 2-9). However, the path-loss values found in this region are so high that it is difficult for any known radar system to detect targets. Troposcatter is an important consideration for certain communications systems and electronic support measures (ESM) receivers.

2.2.5 Absorption

A standard propagation mechanism that was not illustrated in figure 2-9, but should be mentioned, is absorption. Oxygen and water vapor molecules in the atmosphere absorb some energy from radio waves and convert it to heat. The amount of absorption is highly dependent on the radio frequency and is negligible, compared to all the other propagation considerations, below 20 GHz. In addition, absorption by rain drops and other forms of precipitation can be important at some frequencies, but this type of absorption is very hard to model and even harder to acquire environmental data on. For these reasons, absorption effects are ignored in the IREPS program.

2.2.6 Maximum-Range Calculation

Path-loss curves, such as shown in figure 2-9, can be very useful in determining the maximum range capability for a particular EM system. If the maximum path-loss threshold (to just detect, communicate, or intercept) is known, then the maximum range for that system will be the range beyond which the path loss is always greater than the threshold. For example, if a 5000-MHz radar has a one-way path-loss detection threshold of 160 dB, for a 90-percent probability of detection of a one-square-meter target and a known false-alarm rate, then figure 2-9 would indicate a maximum detection range of 25 nautical miles (nmi) if the radar were at 60 feet and the target at 100 feet. The one-way path-loss threshold can always be calculated

from equation 5 if the maximum free-space range is known for the particular system. Again, for the case of the example, if the system is known to have a maximum free-space range of 100 nmi, then equation 5 results in a path-loss threshold of 151.8 dB and figure 2-9 would imply a maximum range (for standard atmospheric conditions) of 21 nmi.

Sometimes, a more convenient form to display the performance capability of an EM system is the vertical-coverage diagram, which shows those areas on a height-versus-range plot, where the path-loss values are always less than the path-loss threshold just described. Figure 2-10 is an example of such a coverage diagram for a standard atmosphere for a typical 200-MHz air-search radar operating at 80 feet above the sea surface and based upon a free-space detection range of 100 nmi. The shaded area in the diagram represents the area in which the path loss is less than the threshold for detection and, therefore, represents the area where the radar would be expected to detect air targets. The display clearly shows the effects of the interference region with the lobes that extend out to 200 nmi and the deep interference nulls that reduce the detection range to within 40 nmi. The lower edge of the bottom lobe, determined by calculations in the diffraction region, is the maximum range for each altitude. The curved-earth display is usually used in the coverage diagram because it has been found easy to understand and it simplifies some of the computer routines used to generate the coverage diagram.

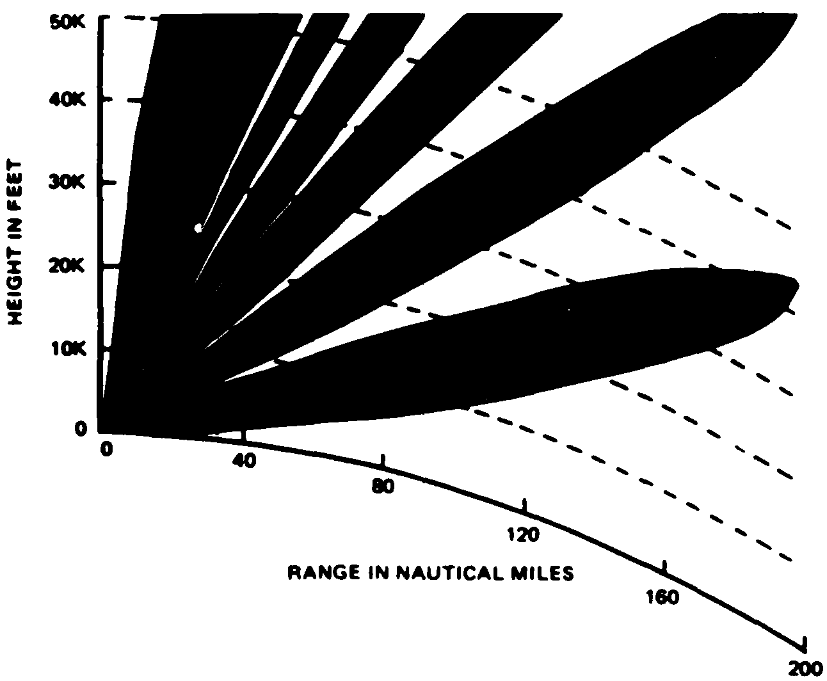


Figure 2-10. Coverage diagram for a 200-MHz air-search radar at 80 ft for a standard atmosphere and based on a free-space detection range of 100 nmi.

2.3 SURFACE-BASED DUCTS FROM ELEVATED REFRACTIVE LAYERS

Over ocean areas, there often exists a cool, moist, marine air mass extending vertically from the ocean surface to an altitude of up to a few hundred meters. The air mass well above this altitude can be much warmer and drier than the marine air, for a variety of reasons, and can create a transition region in which the air warms and dries rapidly with increasing altitude. The warming and drying of the air causes the modified refractivity to decrease with height, thus forming a trapping layer (figure 2-11). As discussed earlier, if the M-value at the top of the trapping layer is less than the M-value at the ocean surface, a surface-based duct will be formed. To some extent, this kind of duct will trap EM signals at all frequencies of concern, independent of the height of the trapping layer, and will generally give extended radar detection range of surface targets, as illustrated in figure 2-12.

In addition, surface-based air-search radars can be dramatically affected by surface-based ducts in the detection of air targets flying within the duct. Figure 2-13 shows a coverage diagram for an air-search radar having the same parameters as in figure 2-10, but in the presence of a 1000-foot surface-based duct. Note that the detection of air targets flying within the first 1000 feet is possible at ranges up to 115 nmi, which is about three times as far as they could have been detected in a standard atmosphere. The amount of range enhancement within the duct is dependent on the radar frequency, with higher frequency radars giving greater detection ranges. Note that the lowest interference lobes have been refracted downward, compared to the corresponding lobes shown for a standard atmosphere in figure 2-10. Such downward refraction is typical in the presence of surface-based ducts.

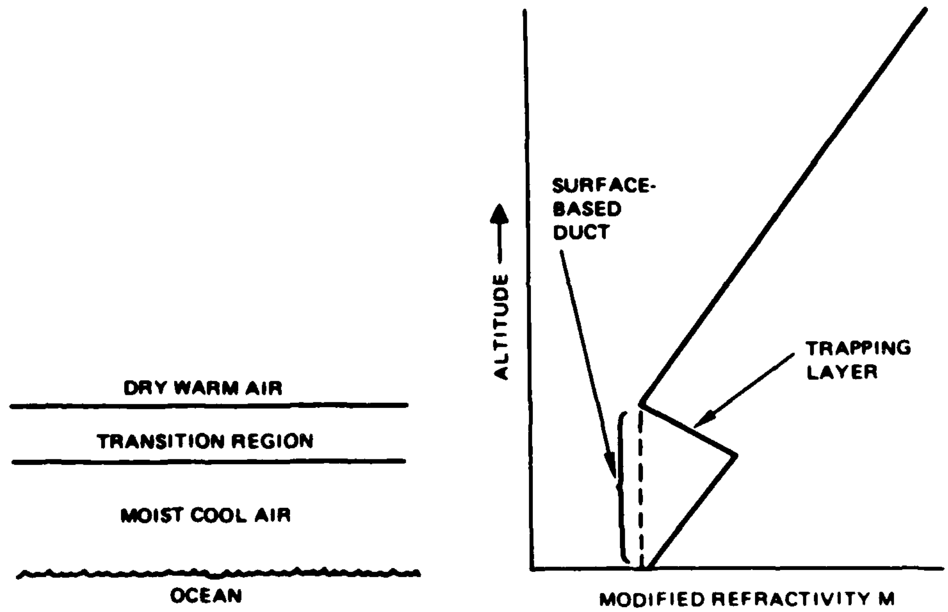


Figure 2-11. Air masses and transition region responsible for the trapping layer and resulting surface-based duct (shown on the right).

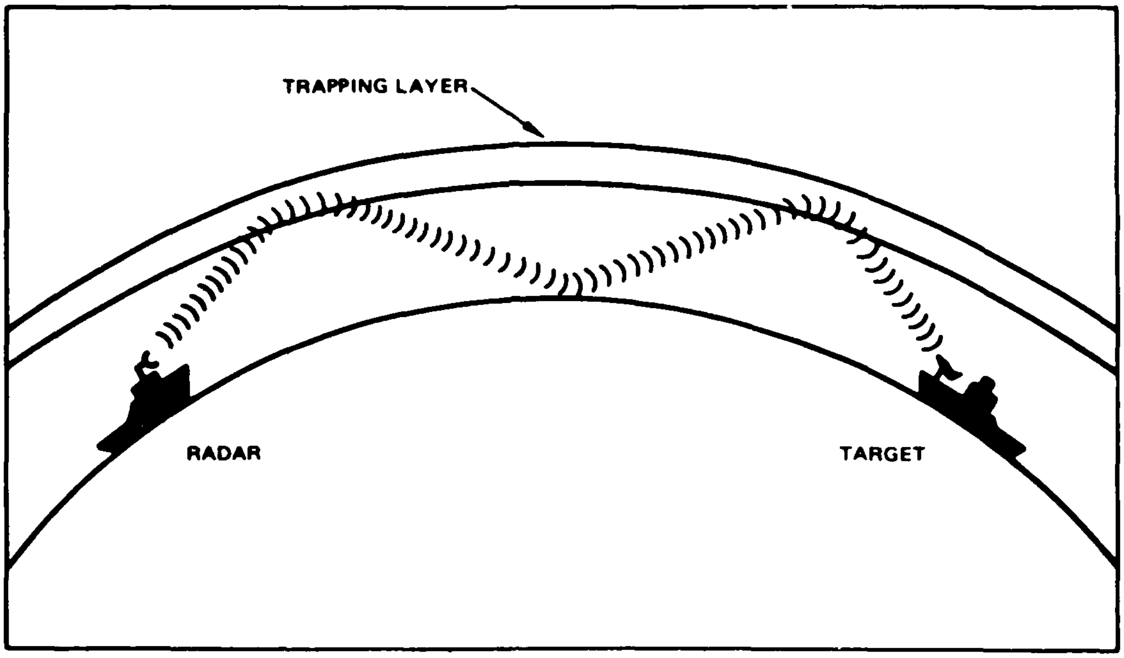


Figure 2-12. Radar wave path for a surface-based duct created by an elevated trapping layer.

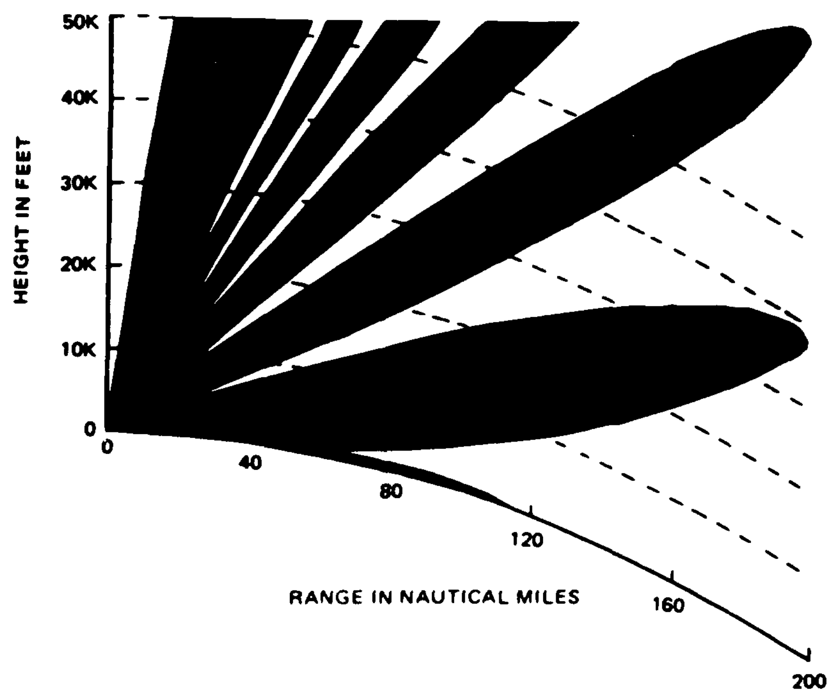


Figure 2-13. Coverage diagram for a 200-MHz air-search radar at 80 ft for a 1000-ft-high surface-based duct and based on a free-space detection range of 100 nmi.

Surface-based ducts also greatly affect communications and EW systems, with the maximum effects occurring when both the transmitter and receiver are within the duct. Shipboard ESM receivers can benefit particularly from this type of duct, which can result in intercept ranges dramatically greater than those under standard atmospheric conditions. In addition, ship-to-ship uhf communications (or ship-to-air for low-flying aircraft) can be enhanced to many times the normal communications range.

The rate of occurrence of surface-based ducts created by elevated refractive layers depends on geographic location and season. They are usually rare at the extreme northern or southern latitudes (occurring perhaps 1 percent of the time, or less), but can occur up to as much as 20 to 40 percent of the time in some important operational areas such as the southern California offshore area, the eastern Mediterranean or the northern Indian Ocean. Surface-based ducts also tend to occur more often during the warmer months. On a day-to-day basis, surface-based ducts can only be detected by making some measurement of the refractivity of the lower atmosphere at least up to 1 kilometer (3000 ft). These measurements are normally made by using either a radiosonde or a microwave refractometer.

2.4 ELEVATED DUCTS

When the transition region described in the previous section occurs at an altitude higher than necessary to produce a surface-based duct, an elevated duct is formed. The N and M unit profiles typical of an elevated duct were previously discussed and illustrated in figure 2-5. It should be noted that the meteorological process responsible for both surface-based and elevated ducts is identical; namely, the transition between two differing air masses creates a trapping layer. In fact, a surface-based duct can become an elevated duct, and vice versa, by relatively small changes in the strength or vertical location of the trapping layer.

Although very low elevated ducts can give enhanced performance ranges to surface-based EM systems, the most dramatic effects caused by elevated ducts are for airborne EM systems. An airborne early-warning radar, for example, can utilize elevated ducts to increase its detection range for targets located within the elevated duct if the radar is also in the duct. Figures 2-14 to 2-16 illustrate the effect of a strong elevated duct on a typical airborne radar, with a 150-nmi free-space detection range, for three radar altitudes. The elevated duct occurs between 15,000 and 17,000 feet. Figure 2-14 shows the enhanced range capability within the duct if the radar is located at 16,000 feet. Notice, however, the large gap in coverage beginning at about 40 nmi and extending outwards above the elevated duct. This gap is often referred to as a "radar hole" and is caused by the trapping of that portion of the wave front within the duct that would normally be in the gap. Actually, the term "radar hole" is not a very good description of the effect because it is possible to detect targets in certain cases within this region due to energy that escapes or leaks out of the duct or propagates to this region via other paths or mechanisms. Generally, however, the detection of air targets in the gap region is significantly reduced and the term "radar hole" has become widely accepted.

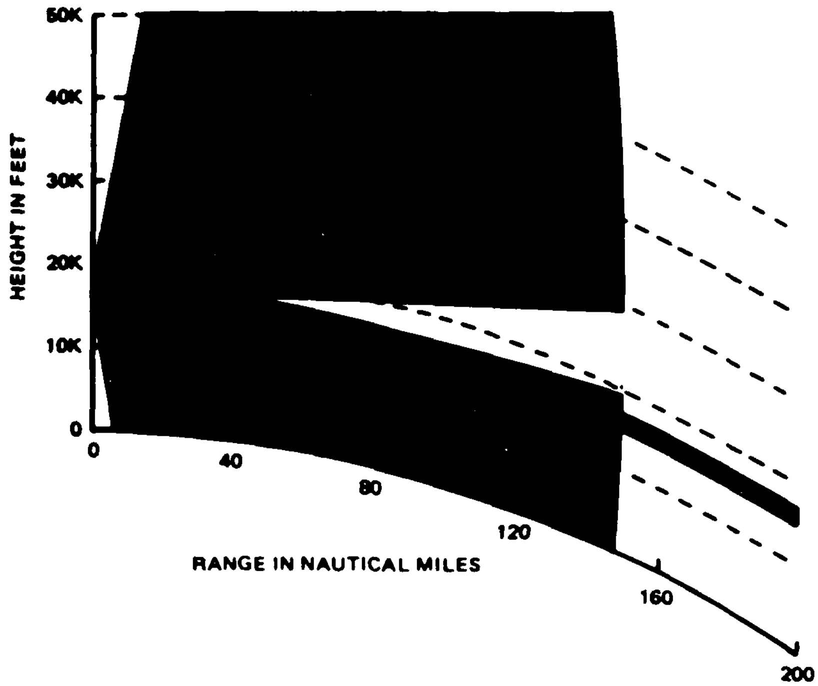


Figure 2-14. Coverage diagram for a typical airborne early-warning radar at 16-kft altitude with 150 nmi free-space detection range in the presence of a 15-to 17-kft elevated duct.

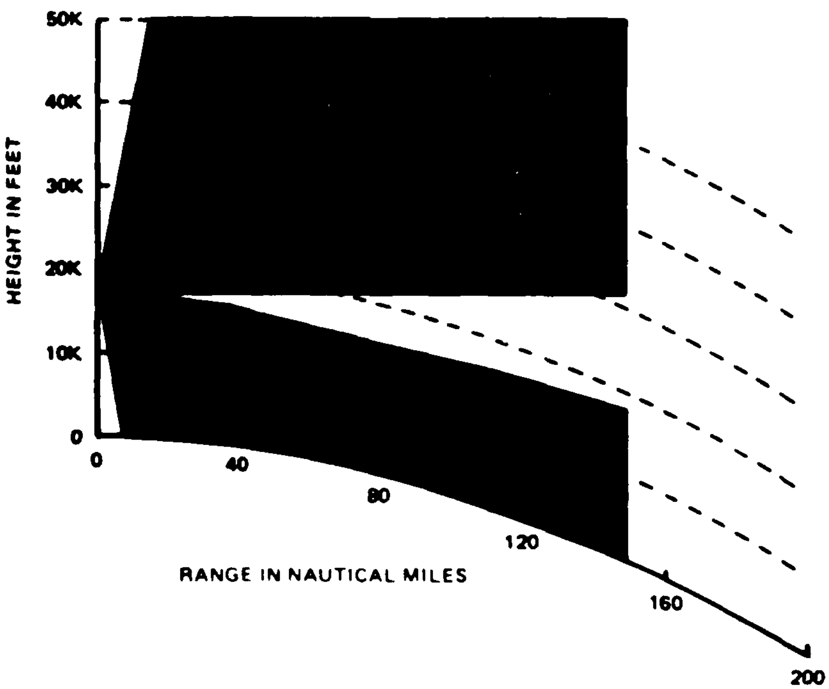


Figure 2-15. Coverage diagram for a typical airborne early-warning radar at 17-kft altitude with 150 nmi free-space detection range in the presence of a 15-to 17-kft elevated duct.

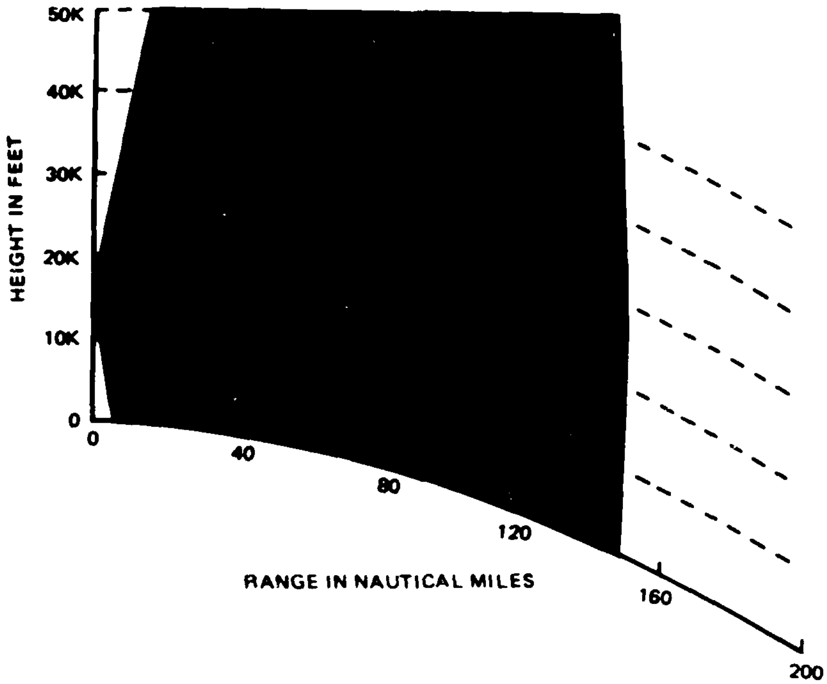


Figure 2-16. Coverage diagram for a typical airborne early-warning radar at 15-kft altitude with 150 nmi free-space detection range in the presence of a 15-to 17-kft elevated duct.

Figure 2-15 shows the effect of moving the radar up to the very top of the duct at 17,000 feet, which results in no enhanced detection capability within the duct but still creates a large hole in the coverage diagram. If the radar were to be placed at even higher altitudes, the radar hole would begin at increasing ranges and become smaller until, finally, the hole would begin at a range exceeding the normal maximum detection range and would become inconsequential. In fact, figure 15 shows the worst altitude to place the radar, since the largest hole will result.

Figure 2-16 shows the effect of placing the radar at the very bottom of the duct, at 15,000 feet, which results in no hole at all. Any radar altitude below an elevated duct will never result in a radar hole and can, therefore, be the optimum location to minimize the radar hole problem. However, if the elevated duct is low enough, then being below it can cause a reduced horizon problem that can affect overall radar coverage. In the example, the radar is high enough so that the radar horizon is in excess of the maximum range of the radar, so there is no reduced coverage.

Elevated ducts can affect air-to-air communications and ESM intercept ranges in much the same way as the radar cases described above. The effects are somewhat frequency-dependent for all EM systems, with the higher frequencies being the most likely to follow the effects illustrated by the radar examples. Lower frequencies may not be trapped sufficiently to cause all the effects illustrated.

To properly assess the effects of elevated ducts, a measurement of the refractivity of the atmosphere is needed, which is usually accomplished with a radiosonde or microwave refractometer.

2.5 EVAPORATION DUCTS

A very persistent ducting mechanism is created over ocean areas by the rapid decrease of moisture immediately above the ocean surface. For continuity reasons, the air adjacent to the ocean is saturated with water vapor and the relative humidity is thus 100 percent. This high relative humidity decreases rapidly in the first few meters to an ambient value which depends on varying meteorological conditions. The rapid decrease of humidity initially causes the modified refractivity M to decrease with height; but at greater heights, the humidity distribution will cause M to reach a minimum and, thereafter, increase with height, as illustrated in figure 2-17.

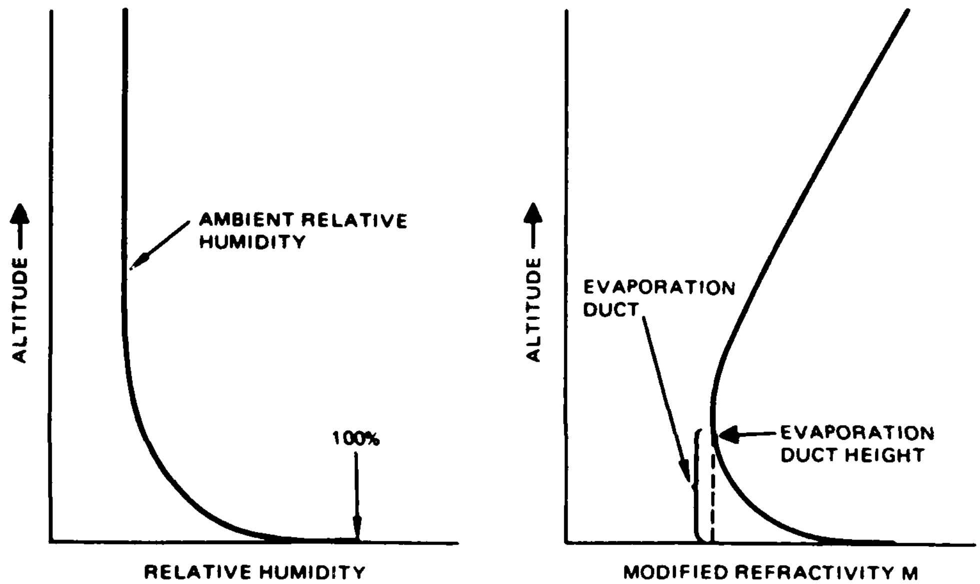


Figure 2-17. Relative humidity and modified refractivity M versus altitude for an evaporation duct.

The height at which M reaches a minimum value is called the evaporation duct height, and is a measure of the strength of the evaporation duct. The evaporation duct, which extends from the surface up to the duct height, is much thinner and weaker than the surface-based ducts described earlier. As a result, the effect that the evaporation duct will have on EM systems is very dependent on the particular frequency and, to a lesser extent, on the height of the antenna above the water. Generally, the evaporation duct will only affect surface-to-surface EM systems, although some effects can occur for relatively low-flying aircraft. It must be emphasized that the evaporation duct height is only a measure of the strength of the duct and is not a height below which an antenna must be located to give extended ranges. For a given surface-search radar, and for sufficiently large duct heights, surface targets can be detected at ranges significantly beyond the horizon, as illustrated in figure 2-18. The frequency of occurrence of duct heights sufficiently large to give beyond-the-horizon detection capability to a particular radar varies significantly according to geographic location, season, and time of day. Generally,

duct heights will be greater at latitudes nearer the equator, and during the summer season. For example, duct heights large enough to extend the detection range of a typical C-band (6 GHz) surface-search radar occur 61 percent of the time in the eastern Mediterranean during the summer, but only 3 percent of the time in the Norwegian Sea during the winter.

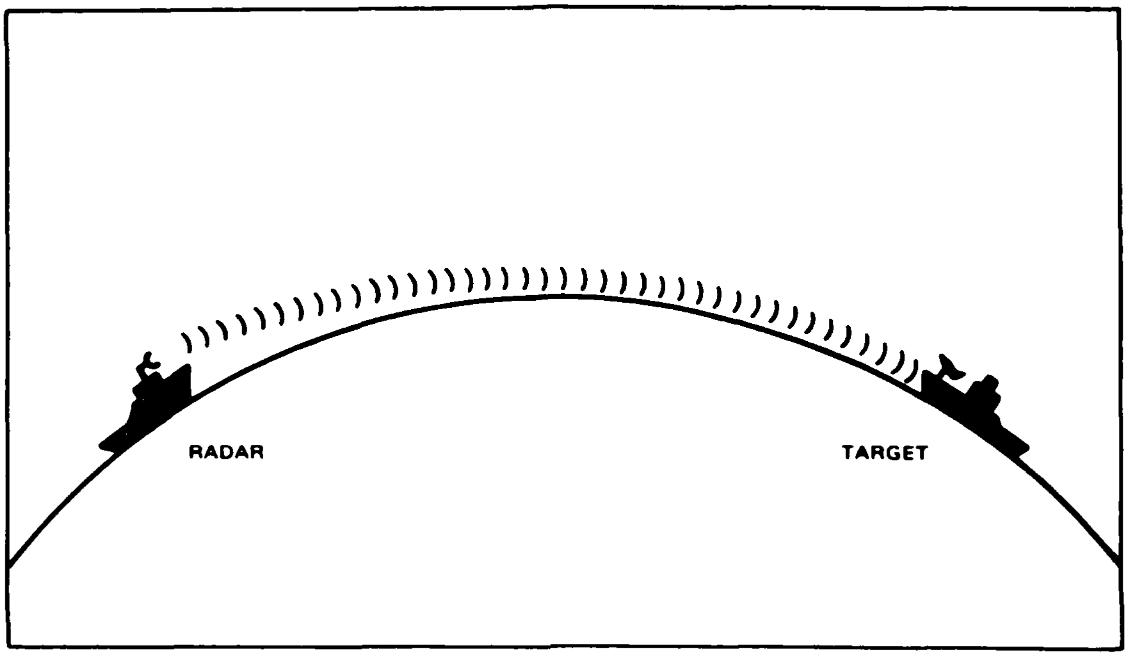


Figure 2-18. Radar wave path under evaporation ducting conditions resulting in beyond-the-horizon detection.

To illustrate these concepts, figure 2-19 shows the relationship between detection range and evaporation duct height for a C-band surface-search radar. The radar antenna in this case is at 33.5 meters (110 feet) above the sea surface and a 35,000-square-meter radar cross-section target is assumed, corresponding to a naval warship of destroyer size. The detection range has been calculated based on a 90-percent probability of detection, a 1 in 10 to the 8th false-alarm rate, a steady target, and a 5-decibel system loss. Figure 2-19 shows a detection range of 19.5 nmi (corresponding closely to the normal radar horizon) for a duct height of zero and increasing detection range for increasing duct heights up to a maximum of approximately 19 meters at the C-band frequency. The detection ranges then decrease as the duct height increases until a minimum of approximately 26 nautical miles is reached. This range is still greater than if no duct were present. The detection ranges decrease because the EM energy becomes confined lower and lower in the duct as the duct height increases. The peak in the detection range, as shown in figure 2-19, occurs at higher duct heights for lower frequencies and at lower duct heights for higher frequencies. At higher duct heights, there may be cases where radar contacts (or communication links) may be established at ranges greater than indicated in figure 2-19, but these contacts may fade or be lost as the relative range changes.

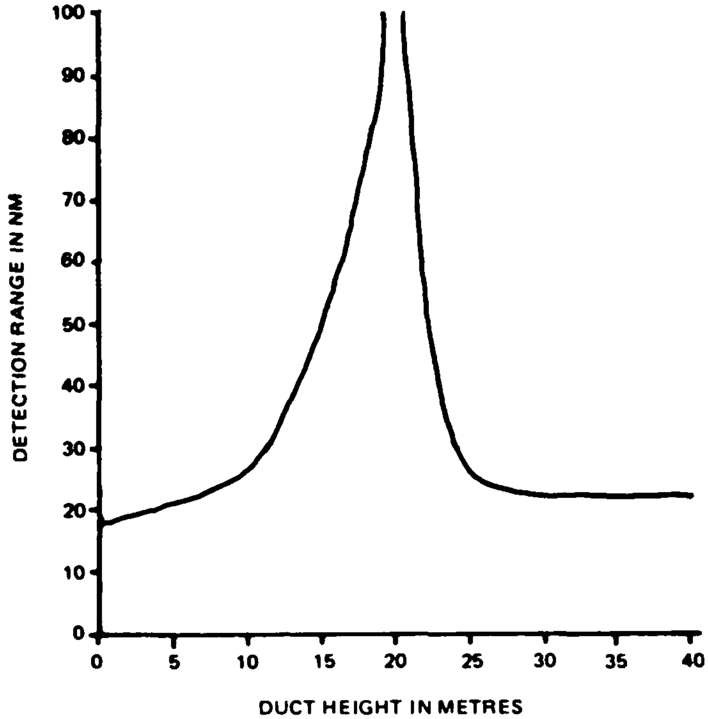


Figure 2-19. Detection range versus evaporation duct height for a C-band radar with an antenna height of 33.5 meters and 90-percent probability of detection of a destroyer-sized surface target.

Generally, the evaporation duct is only strong enough to affect EM systems operating above 3 GHz, although systems with frequencies down to about 1 GHz can benefit from the mechanism on occasion. ESM intercept ranges for surface-to-surface paths can be greatly extended by the evaporation duct and certain communications systems could also experience enhanced ranges when both terminals are near the ocean surface. Ship-to-ship uhf communications frequencies are too low to benefit from the evaporation duct, but uhf ranges can be extended by surface-based ducts as explained in section 2.3.

The proper assessment of the evaporation duct can only be performed by making surface meteorological measurements and inferring the duct height from the known meteorological processes occurring at the air/sea interface. The evaporation duct height cannot be measured by using a radiosonde or microwave refractometer.

2.6 SEA CLUTTER AND DUCTING

Under certain circumstances, a radar's performance is limited by radar returns from the sea surface known as sea clutter. If the sea-clutter return is stronger than a target return at the same range, it will be difficult or impossible to detect the target. Many radars employ sophisticated signal-processing techniques in an attempt to minimize sea-clutter return. In the presence of surface-based or evaporation ducts, however, the sea-clutter return can be greatly enhanced and may overcome any signal-processing gains. In addition, the horizontal extent of sea clutter can be greatly extended during ducting conditions and can mask targets over much greater ranges than normal.

Figure 2-20 illustrates how a surface-based duct created by an elevated layer can result in sea-clutter return, from a significant range, that can mask air targets at the same range. The strength of the sea-clutter return is very dependent on the strength of the duct and on the roughness of the sea surface, which is controlled primarily by the surface wind speed and direction. A surface-based duct, such as that illustrated in figure 2-20, usually results in several discrete range intervals of high sea clutter because of the typical propagation path in a surface-based duct (figure 2-12). These discrete intervals are normally independent of azimuth angle, which can give the appearance of sea-clutter rings centered at the radar when viewed on a PPI display. Evaporation ducts, on the other hand, will result in continuous, enhanced sea-clutter return with range.

Airborne radars are also affected by sea clutter and can have their performance impaired by enhanced clutter, particularly for surface-search applications where the target of interest is of small radar cross section, such as a periscope.

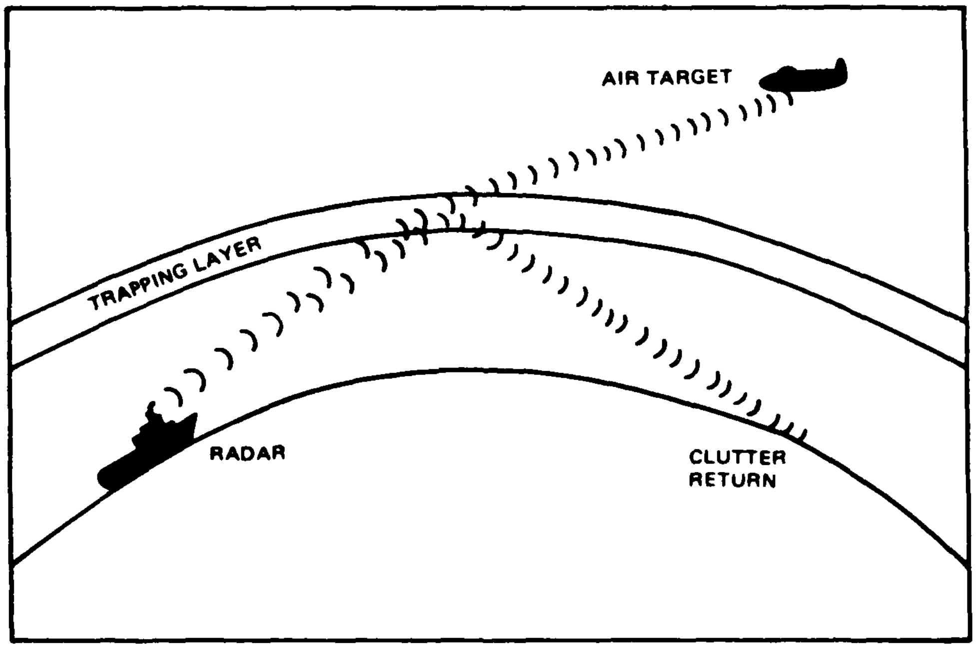


Figure 2-20. Air-search radar geometry showing possible sea-clutter return from rough sea surface at same range as air target for surface-based duct.

2.7 METEOROLOGICAL MEASUREMENTS TO ASSESS REFRACTIVE EFFECTS

2.7.1 Surface-Based and Elevated Ducts

To determine the presence of either a surface-based duct or an elevated duct, measurements of the vertical distribution of the refractivity or of the air temperature and humidity must be made. There are two primary methods by which such measurements are made, namely, the microwave refractometer and the radiosonde. The IREPS program can use inputs from either the refractometer or the radiosonde in assessing refractive effects.

The microwave refractometer is an aircraft-mounted device which directly measures refractivity. These refractivity measurements may be recorded on a magnetic cassette tape for post-flight processing. Within the IREPS program, this processing includes calculations of refractivity, N, or modified refractivity, M, as a function of altitude. These values are used in turn to determine the presence and vertical extent of ducts as previously discussed.

The radiosonde is a balloon-borne expendable package that measures temperature, humidity, and pressure as the package ascends through the atmosphere. The measurements are sent via a small radio transmitter to a receiver at the surface where they are recorded. These environmental measurements are then translated into refractivity as a function of altitude.

2.7.2 Evaporation Ducts

The evaporation duct height may not be measured with either the microwave refractometer or the radiosonde. To determine the evaporation duct height at any given time and place, a method has been devised that requires measurements of sea-surface temperature and, at a convenient height above the sea surface, air temperature, humidity, and wind speed. This method is based on the known variation of temperature and humidity near the air/sea interface.

The measurement of the sea-surface temperature is best accomplished with an accurate thermometer and a small bucket which has been lowered into water undisturbed by the ship's wake. Boiler-water injection temperature measurements are generally very inaccurate for the purposes required here and should be avoided if at all possible. It is recognized that obtaining a good sea-surface temperature measurement, while underway at reasonable ship speeds, can be very difficult. For ships so equipped, satisfactory measurements may be attained through the use of a bathythermograph.

A single measurement of air temperature and relative humidity is required at any convenient height above 6 meters (20 feet), but must be made in a way to minimize any ship-induced effects such as convective heating from exhaust vents or solar-heated surfaces. These measurements are best performed with a psychrometer on the most windward side of the ship.

The wind speed may be obtained from either the ship's anemometer or a hand-held anemometer, both of which must be corrected for the ship's course and speed. With these required inputs, the IREPS program can calculate the evaporation duct height and then use the duct height in assessing its effects on the various EM systems.

3. PRODUCTS AND UTILITIES

3.1 IREPS PRODUCTS

There are seven basic products that can be generated by IREPS revision 3.0. These products are dependent upon the proper entry of environmental, electromagnetic systems', and electro-optic systems' data as explained within section 4.2. The seven products are the following:

(1) Propagation conditions summary
(2) Coverage display
(3) Loss display
(4) AEW stationing aid
(5) Surface-search radar range table
(6) ESM intercept range table
(7) FLIR Performance range summary

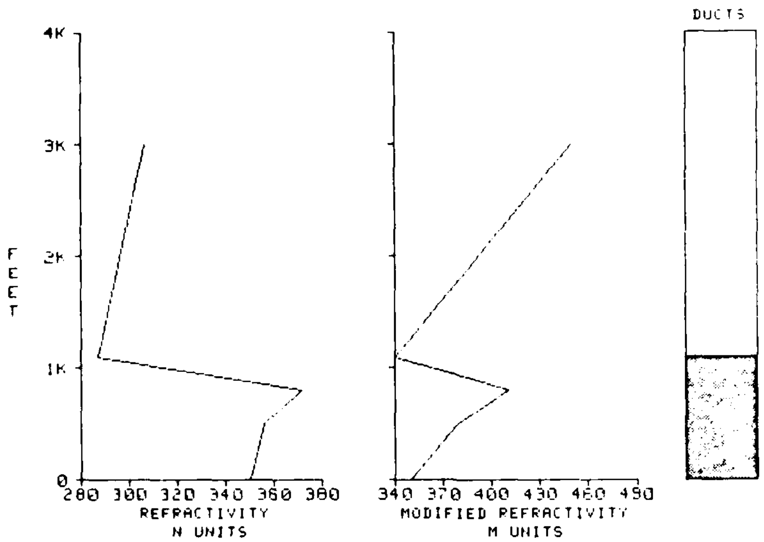
Each product is produced on an 8-1/2- by 11-inch printout consisting of a mixture of alphanumeric labels and graphics displays. There are a number of other displays and utilities within IREPS designed to assist in the determination of needed parameters for an IREPS product and assist the operator in entering data, selecting products, and otherwise running the program but these are not considered IREPS products.

3.1.1 Propagation Conditions Summary

Figure 3-1 shows an example of the propagation conditions summary. This product is used to show the existing refractive conditions for the location and date/time of the environmental data set and to give a plain-language narrative assessment of what effects may be expected on an EM system-independent basis. The summary shows refractivity in N-units and modified refractivity in M-units as a function of altitude. The presence and vertical extent of any ducts are shown by shaded areas on the vertical bar to the right side of the product. In this case, there is a surface-based duct created by an elevated layer extending up to about 1100 feet. The wind speed and evaporation duct height are listed numerically on this product. Near the bottom of the product are three categories labeled SURFACE-TO-SURFACE, SURFACE-TO-AIR, and AIR-TO-AIR in which brief statements occur concerning the general performance of EM systems in each geometry category. The statements are system-independent assessments and are true only in a general sense. For specific systems, one of the other products must be generated to obtain a proper assessment of its performance. Finally, the appropriate setting for the SPS-48 to correct for surface refractivity effects on its height-finding capability is also indicated.

```
IREPS  3.00                                    Date: 02 16 87
                 **** PROPAGATION CONDITIONS SUMMARY ****
LOCATION: OPERATION AREA B
DATE/TIME: JAN 15, 1987 - 000

WIND SPEED 13 knots                  EVAPORATION DUCT HEIGHT= 10 feet
VISIBILITY 8 nautical miles
```




```
SURFACE-TO-SURFACE
   EXTENDED RANGES AT ALL FREQUENCIES

SURFACE-TO-AIR
   EXTENDED RANGES FOR ALTITUDES  UP TO  1,100  FEET
   POSSIBLE HOLES  FOR ALTITUDES  ABOVE  1,100  FEET

AIR-TO-AIR
   EXTENDED RANGES FOR ALTITUDES  UP TO  1,100  FEET
   POSSIBLE HOLES  FOR ALTITUDES  ABOVE  1,100  FEET
   HOLES FROM SUB- OR SUPER- REFRACTIVE LAYERS MAY EXIST ABOVE 0  FEET

SURFACE REFRACTIVITY: 350 --SET SPS-48 TO 344
```

Figure 3-1. Propagation conditions summary.

3.1.2 Coverage Display

Figure 3-2 is an example of an IREPS coverage display product that shows the area of coverage on a curved-earth, range-versus-height plot. The shaded areas in the plot correspond to the area of detection or communication for the operator-specified EM system. Up to four densities of shading may be employed, with various densities corresponding to variables such as target RCS, probability of detection, transmitter power, etc.

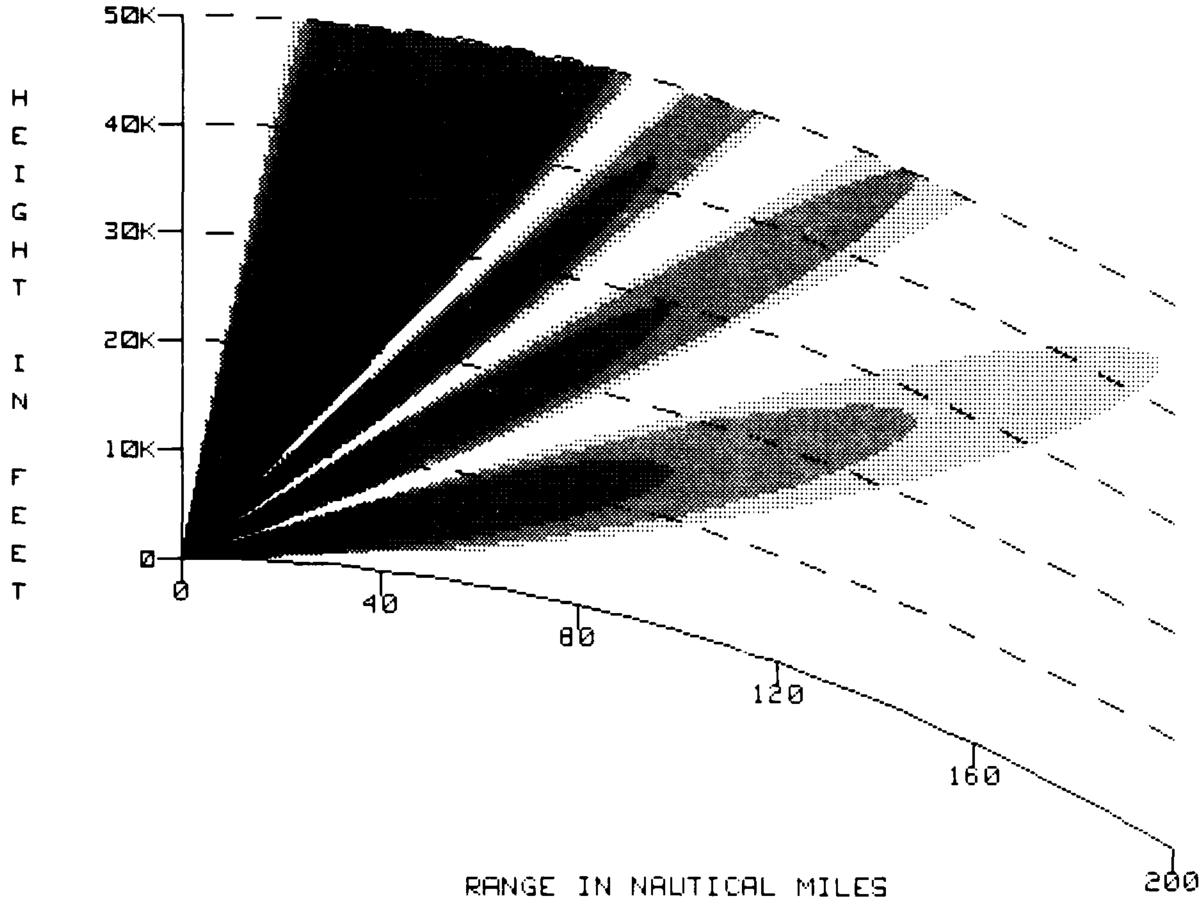
For airborne systems, only one shading is employed, and the degree of shading has no relationship to the signal level. The lines, which are drawn on a dot-matrix display, often show some patterns or distinct lines within a contour. These are called moire patterns and result from the digital nature of the display. The IREPS program minimizes the number of rays plotted to limit the amount of time it takes to produce an airborne system coverage diagram, and the ray spacing gives rise to the moire patterns.

IREPS 3.00 Date: 02/16/87

**** COVERAGE DISPLAY ****

LOCATION: 32 05N - 118 43W
DATE/TIME: 1200Z 15 MAR 87

AIR-SEARCH RADAR



USER OPTIONAL LABEL LINE NUMBER ONE
USER OPTIONAL LABEL LINE NUMBER TWO

SHADED AREA INDICATES AREA OF DETECTION OR COMMUNICATION

TYPE OF PLATFORM:SURFACE
TRANSMITTER OR RADAR ANTENNA HEIGHT: 100 FEET
FREQUENCY: 200 MHZ
POLARIZATION: HORIZONTAL
FREE SPACE RANGES: 25 50 75 100 NAUTICAL MILES
ANTENNA TYPE: SINX/X
VERTICAL BEAM WIDTH: 20 DEGREES
ANTENNA ELEVATION ANGLE: 0 DEGREES

Figure 3-2. Coverage display.

In addition to the basic coverage display plot, this product also includes the location and date/time labels for the refractivity condition upon which it is based plus a numeric listing of the system parameters used to generate the coverage display.

3.1.3 Loss Display

Figure 3-3 is an example of a path-loss display product that shows one-way path loss in decibels versus range. The horizontal dashed line in the display represents the threshold for detection, communication, or intercept. For ranges out to the path-loss curve/threshold line intersection, detection, communication, or signal interception can be expected, while no detection, communication, or signal interception is expected for ranges in excess of the intersection point. As with the coverage display, up to four threshold lines (one for an airborne system) may be employed representing such variables as receiver sensitivity or transmitter power. In addition to the basic loss display, this product also includes the location and date/time labels for the refractivity condition upon which it is based plus a numeric listing of the system parameters used to generate the loss display.

3.1.4 AEW Stationing Aid

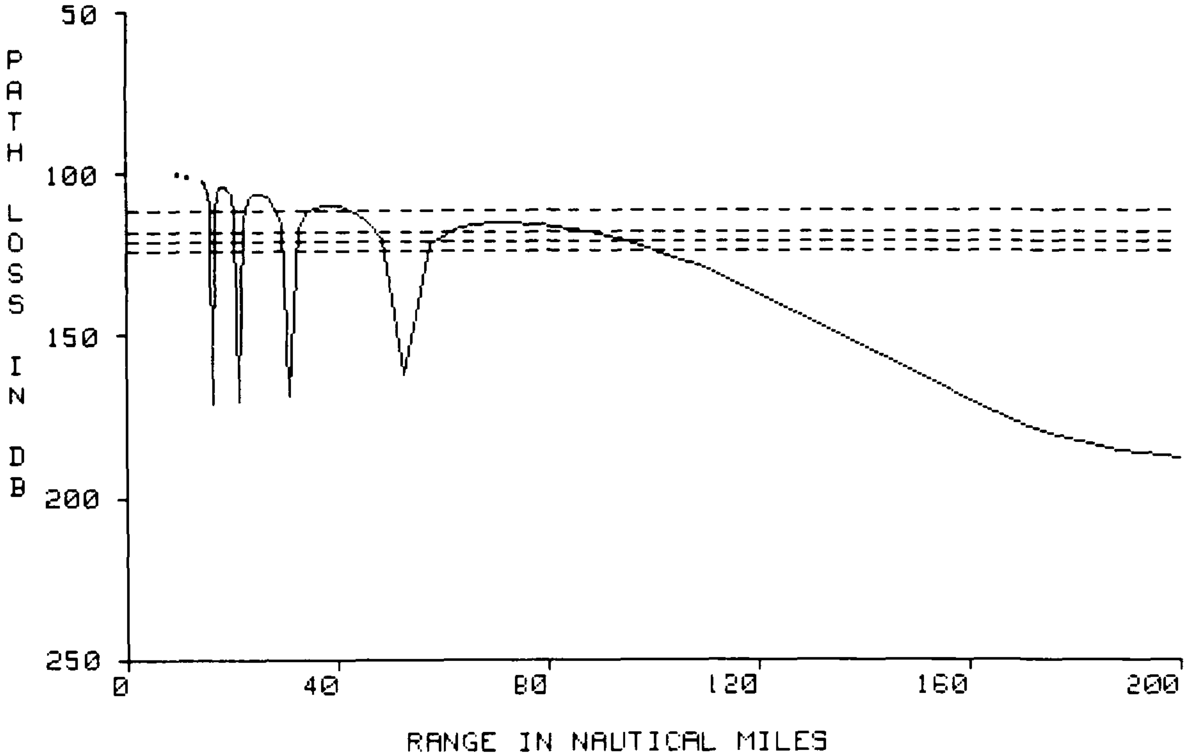
The AEW aircraft stationing aid is designed to show the refractive distortion of normal propagation at a given range for various combinations of radar/transmitter and target/receiver altitudes. Figure 3-4 is an example of the AEW aircraft stationing aid which shows the distortion at a range of 150 nmi on a height-versus-height plot for an elevated duct between 9000 and 10,000 feet. The shaded area in the plot corresponds to radar/transmitter and target/receiver altitude combinations for which detection, communication, intercept, or jamming may occur, depending upon specific system characteristics. The fully shaded square between 9000 and 10,000 feet indicates the radar/transmitter and target/receiver altitude combinations which are within the duct, implying multipath with possible signal fading in addition to over-the-horizon propagation at longer ranges. Associated with the trapping layer is the crescent-shaped clear area in the middle of the display. This clear area corresponds to altitude combinations which occur within the radar/radio hole. There is reduced detection, communication, intercept, or jamming capability for altitude combinations within the clear area. The more heavily shaded area along the lower left of the clear area indicates multipath propagation due to the presence of the trapping layer. The clear area in the extreme lower left of the display represents those altitude combinations which are below the radar/radio horizon. The bar chart on the right indicates the type and vertical extent of anomalies in the refractivity profile: ducting, superrefraction, and subrefraction.

IREPS 3.00 Date: 02/16/87

**** LOSS DISPLAY ****

LOCATION: 32 05N - 118 43W
DATE/TIME: 1200Z 15 MAR 87

AIR-SEARCH RADAR



USER OPTIONAL LABEL LINE NUMBER ONE
USER OPTIONAL LABEL LINE NUMBER TWO

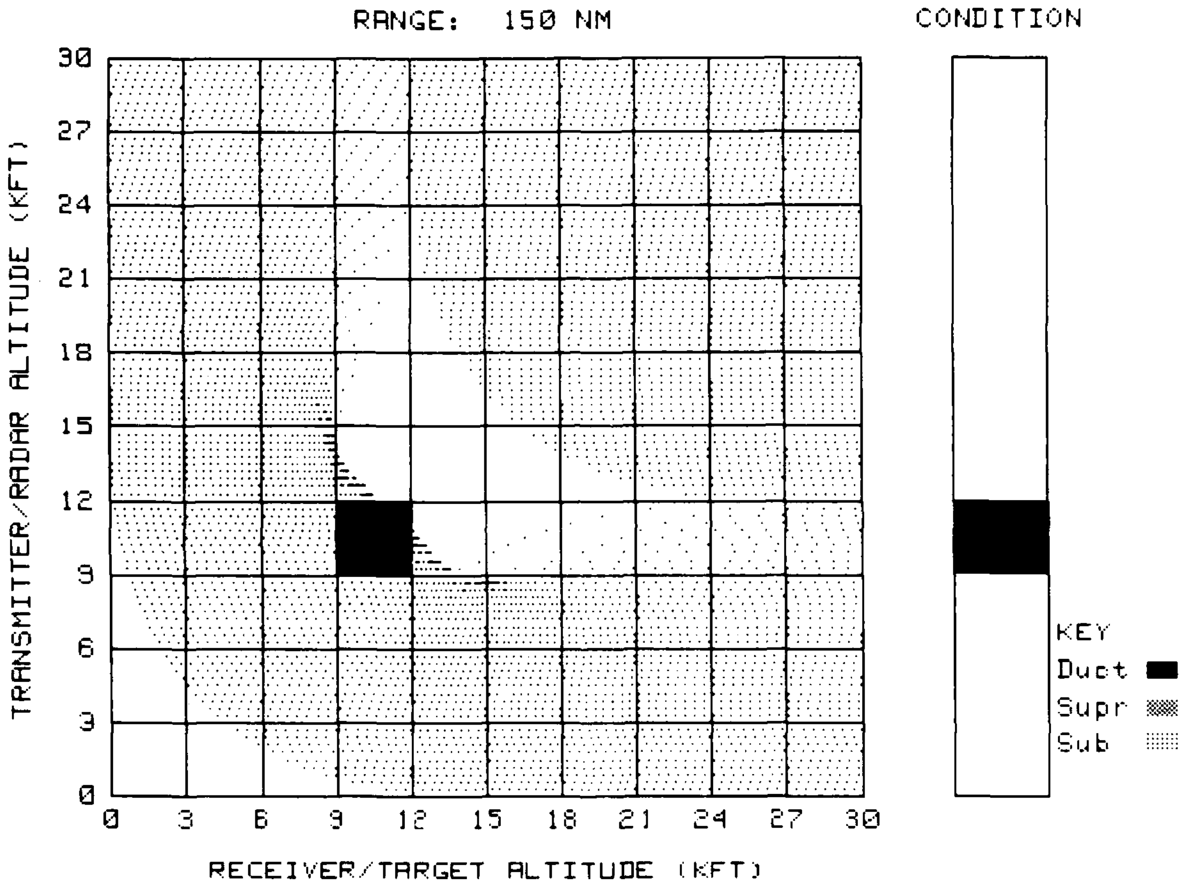
TYPE OF PLATFORM:SURFACE
TRANSMITTER OR RADAR ANTENNA HEIGHT: 100 FEET
RECEIVER OR TARGET HEIGHT: 10000 FEET
FREQUENCY: 200 MHZ
POLARIZATION: HORIZONTAL
FREE SPACE RANGES: 25 50 75 100 NAUTICAL MILES
ANTENNA TYPE: SINX/X
VERTICAL BEAM WIDTH: 20 DEGREES
ANTENNA ELEVATION ANGLE: 0 DEGREES

Figure 3-3. Loss display.

IREPS 3.00 Date: 02/12/87

**** AEW DISPLAY ****

LOCATION: NOT SPECIFIED
DATE/TIME: ELEV DUCT 9-12 Kft



VARIATIONS IN SHADED AREA INDICATE DISTORTIONS IN PROPAGATION AT THIS RANGE

DARKEST SHADING INDICATES RAY CONVERGENCE AND MULTIPATH
LIGHTEST SHADING INDICATES RAY DIVERGENCE

Figure 3-4. AEW stationing aid.

3.1.5 Surface-Search Radar-Range Table

Figure 3-5 shows the surface-search radar-range-table format. The purpose of this display is to provide detection–range predictions for an operator–specified surface-search radar against an operator–specified table of surface targets.

Three range values are given in the tables. These ranges of minimum, average, and maximum represent ranges at which vessels of the classes listed should be detected under the environmental conditions entered in IREPS. All three ranges represent a 90-percent probability of detection, but the minimum and maximum values represent the extreme variations of the radar cross section (RCS) of the target vessel with aspect. An example of a fairly typical variation of RCS with aspect is given in figure 3-6. The three lines plotted on the polar diagram are the 20, 50, and 80 percentile values of the RCS distribution functions, inner to outermost curves, respectively. The RCS values are plotted in decibels above 1 square meter. The fluctuations with aspect of 10 dB or greater can cause the detection range to vary an order of magnitude between the minimum and maximum values under the appropriate ducting conditions.

```
IREPS  3.00                                          Date: 02/16/87
                     **** SURFACE SEARCH RADAR RANGE TABLE ****
LOCATION: OPERATION AREA A
DATE/TIME: 0100Z 12 MAR 87

                     SURFACE SEARCH RADAR: SYSTEM 1
```

TARGET	DETECTION RANGE IN NM MIN	AVG	MAX
CV	40.5	43.4	48.5
CG	36.7	39.5	44.2
DD	35.4	38.2	42.9
FF	33.4	36.3	41.1
OSA	28.0	30.5	34.7

```
SURFACE BASED DUCT HEIGHT=  0 METERS.
                            0 FEET.
```

Figure 3-5. Surface-search radar range table format.

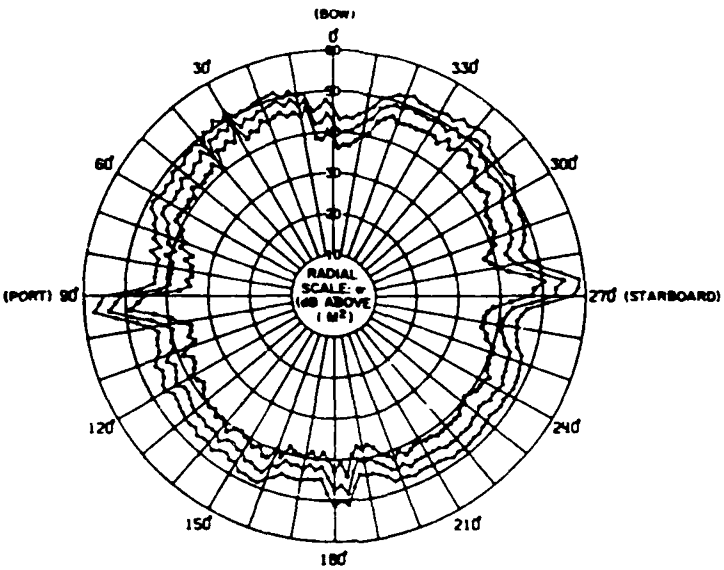


Figure 3-6. Variations of radar cross section with aspect for grazing angle incidence.

3.1.6 Electronic Support Measure (ESM) Intercept-Range Table

This product displays the maximum intercept range for an operator specified Electronic Support Measure (ESM) system against various operator specified emitters. The format of the table is shown in figure 3-7. In addition to the emitter nomenclature or code name, the center or nominal frequency for each emitter is listed in the table. The table is intended to give the user an estimate of the maximum range at which the interception of a particular emitter under the existing environmental conditions can be expected. Conversely, the table can be used to estimate counterdetection of one's own emitters. Note that the evaporation duct parameters must be entered or specified if no surface-based duct is present.

Normal intercept ranges can be greatly extended by the evaporation duct, resulting in intercept of signals well beyond the horizon. Even more dramatically, a surface-based duct from an elevated refractive layer can extend intercept ranges to far in excess of 200 nmi. However, in nature, the assumption of horizontal homogeneity discussed in section 3.3.3 is questionable over these great ranges. Thus very long intercept ranges within a duct will be indicated as 250+, meaning 250 nmi or greater, for terminals within a surface duct.

```
IREPS  3.00                                                   Date: 02/16/87
                              **** ESM INTERCEPT RANGE TABLE ****
LOCAT.ON: OPERATION AREA A
DATE/TIME: 0100Z 12 MAR 87

                              ESM RECEIVER: RECEIVER A

                              EMITTER CLASS: BLUE FORCES
```

EMITTER	FREQ (MHz)	MAXIMUM INTERCEPT RANGE (km)
EMITTER ONE	300	250+
EMITTER TWO	4000	224
EMITTER THREE	5500	
EMITTER FOUR	15000	121

Figure 3-7. ESM intercept range table format.

3.1.7 FLIR Performance-Range Summary

This product displays the 50-percent probability of detection range of various sized targets by an operator-specified forward-looking infrared (FLIR) system operating at various altitudes. The ranges shown are slant-path ranges (actual range between the FLIR system and the target). The format of the table is shown in figure 3-8. As explained within section 4.3.2, use of this product is recommended only for the FLIRs as recommended by NOSC.

3.2 IREPS UTILITIES

There are eight utility functions within IREPS designed to assist in the determination of needed parameters for IREPS products and assist the operator in program and data manipulation. These utilities are the following:

(1) List user data files
(2) Edit user data files
(3) List current environmental data
(4) List historical environment
(5) Radar free-space detection-range calculations
(6) Free-space intercept-range calculations
(7) Surface refractive conditions
(8) Reconfigure IREPS program

A detailed discussion of these utility functions and how to use them is presented in section 4.2.4.

IREPS 3.00 Date: 02/16/87

**** FLIR PERFORMANCE RANGE SUMMARY ****

LOCATION: 32 05N - 118 43W
DATE/TIME: 1200Z 15 MAR 87

FLIR A

FLIR ALTITUDE FEET	----- NOMINAL FLIR RANGE(NM) FOR TARGET DETECTION ----- CHARACTERISTIC TARGET TYPE		
	CRUSIER	DESTROYER	FRIGATE
500	31.8	31.8	31.8
1000	42.3	42.3	42.3
1500	50.4	50.4	50.4
2000	57.2	57.2	57.2
2500	63.2	63.2	63.2
3000	68.6	68.6	68.6
3500	73.6	73.6	71.1
4000	78.2	78.2	71.9
5000	86.7	86.2	73.4
7500	101.3	90.9	78.0
10000	106.5	96.2	82.4
15000	117.1	105.5	89.7
20000	126.0	113.0	95.3
25000	133.4	119.1	100.0
30000	139.6	124.1	103.6
	SURFACE SUB	SNORKEL SUB	PERISCOPE
500	31.8	14.5	7.9
1000	42.3	14.6	8.0
1500	46.4	14.7	8.0
2000	46.6	14.9	8.0
2500	46.9	14.9	8.0
3000	47.5	15.0	8.1
3500	48.1	15.1	8.1
4000	48.7	15.2	8.1
5000	50.0	15.3	8.3
7500	52.6	15.7	8.5
10000	55.0	16.1	9.6
15000	58.6	16.8	11.2
20000	61.3	19.2	12.1
25000	63.5	21.1	12.3
30000	65.0	22.5	12.1

Figure 3-8. FLIR performance-range summary format.

3.3 LIMITATIONS OF THE IREPS MODELS

The user needs to be aware of a number of limitations in the IREPS models and resulting products. The IREPS models and software are constantly undergoing revisions, and many of the limitations discussed within this document will be overcome in the future.

3.3.1 Frequency

The frequency range for which the models have been developed is from 100 MHz to 20,000 MHz. Any use of the IREPS program for frequencies outside these bounds is not allowed by the program. The models specifically do not apply to any hf system.

3.3.2 Clutter

The models do not include any effects produced by sea or land clutter in the calculation of radar detection ranges. This shortcoming may be of importance for air-search radars in the detection of targets flying above surface-based or strong evaporation ducts, but is not expected to significantly affect the predicted enhanced detection ranges within a duct. Specifically, for surface-based ducts, the actual detection capability at some ranges may be reduced for air targets flying just above the duct.

3.3.3 Horizontal Homogeneity

The IREPS program does not account for horizontal changes in the refractivity structure. This restriction is not believed to be a serious one within open-ocean areas, since there exists scientific evidence that the atmosphere is horizontally homogeneous about 85 percent of the time for the purpose of making refractive effects assessments. The IREPS operator, and also the users of the IREPS products, should be aware of the changing state of the atmosphere and try to acquire and use refractivity measurements that are appropriate to the planned time and place of pertinent operations.

3.3.4 Antenna Heights

The model that calculates the coverage display for surface-based systems is valid only for antenna heights between 3 and 250 feet, and the program will not accept heights outside these bounds. This should not be a restriction on any normal application for ship-based systems, including submarines operating at periscope depth. In addition, the antenna heights for airborne systems are limited to the maximum height of the coverage display that has been selected.

3.3.5 Interference Effects

The models used within the coverage and loss products for an airborne system do not include interference effects. For airborne systems, the sea-reflected ray is ignored; surface systems are the only systems in which the coverage and loss products include the effects from a sea-reflected ray. A coverage display for a surface system will show three lobes of the interference pattern, starting with the lowest elevation angle. For angles above the last lobe, the spacing between the lobes

becomes very small on the display and only the maximum detection envelope is plotted. A loss display for a surface system will show the interference null locations until the position when the spacing between the nulls is less than one-twentieth of the maximum range. At close in ranges, the minimum path loss, or the interference peak, is plotted to provide an envelope to the tightly spaced null positions.

3.3.6 Absorption

There is no account made of absorption from oxygen, water vapor, fog, rain, snow, or other particulate matter in the atmosphere. Most of these absorption effects are very minor over the valid frequency range of the models and will not affect the predicted ranges. For very heavy precipitation there may be a noticeable effect; but even if the precipitation models existed, it would be difficult or impossible to obtain the required precipitation rates and horizontal extent from which calculations could be made.

3.3.7 Low Elevated Ducts

The IREPS models account for ducting in evaporation ducts, surface-based ducts, and low elevated ducts, provided the transmitter or radar antenna is within the duct. These models do not, however, properly account for the over-the-horizon regions for low elevated ducts when the bottom of the duct is just above the transmitter or radar antenna height. The calculated ranges for the coverage display will generally be less, and the path loss values for the loss display will be greater, than the corresponding actual ranges and path-loss values. The error becomes less the higher the elevated duct is above the transmitter or radar antenna height and should be insignificant when the separation exceeds a few thousand feet. The interference region calculations are correct for low elevated ducts.

3.3.8 Applicability of the Coverage Display

The coverage display can be used for the following applications:

(1) Long-range air-search radars, either 2D or 3D, surface-based or airborne.
(2) Surface-search radars when employed against low-flying air targets.
(3) Surface-to-air or air-to-air communication systems.

The coverage display specifically should not be used for the following applications:

(1) Airborne or surface-based surface-search radars employed against surface targets.
(2) Any type of gun or missile fire-control radar.

It should be pointed out also that it is not the intent of the coverage display model to calculate the maximum radar range for a given radar and target, but rather to show the relative performance of a radar (or communications) system at different altitudes as affected by the environment. It is up to the user to input a free-space range that is appropriate for the application at hand.

4. OPERATING IREPS REVISION 3.0

This section describes the operation of IREPS Revision 3.0, as employed in the Hewlett-Packard 9000 series 500 desk-top computer using the Hewlett-Packard BASIC computer language. The IREPS software will be maintained solely by the Naval Ocean Systems Center. Discrepancies in IREPS products, difficulties encountered while running the program, and questions concerning the use of IREPS Revision 3.0 on IBM-compatible computers or in other computer languages should be directed to:

Commander
Naval Ocean Systems Center
Code 543
San Diego, CA 92152-5000

Autovon: 933-7247 or commercial 619-225-7247

Operation of the computer itself is described within the appropriate Hewlett-Packard manuals provided with the system. It is assumed the operator has an elementary knowledge of directory/file structure and execution of programs.

4.1 HOW TO GET STARTED

IREPS Revision 3.0 is distributed in the form of three double-sided, double-density, 5-1/4 inch flexible diskettes. Diskettes 1 and 2 contain the IREPS program and subprograms. Diskette 3 contains fixed data required for program operation. For operation of IREPS Revision 3.0, the minimum computer configuration is 1.5 megabytes of internal memory and one 5 1/4 inch floppy disk drive. An internal (or external) hard disk with 2 megabytes of free disk space must also be available.

Before attempting to install the IREPS software for the first time, the HP520 BASIC Operating System (OS) must be checked for a proper configuration. Initial load and configuration of the OS is described in the BASIC Software Configuration Manual (BSCM) supplied by HP. The CAT_BOOT utility program, described in the BSCM, is used to obtain a listing of the program names that are resident in the OS. IREPS requires the following binary programs to be installed within the OS:

IO
ERRORS_ENG
MS
MEMORY_VOL
SERIAL
GRAPHICS
HP97062

If these names do not appear on the CAT_BOOT listing, then a new OS (including these binaries) must be made using the BUILD_BOOT utility and the HP BASIC System Boot discs. The BUILD_BOOT utility is described in the BSCM. After verifying proper OS configuration, the IREPS software may be installed.

With the computer turned on and the OS properly configured, insert IREPS diskette number one into the floppy disk drive, type LOAD "INSTALL:INTERNAL",1

With the computer turned on and the OS properly configured, insert IREPS diskette number one into the floppy disk drive, type LOAD "INSTALL:INTERNAL",1 and press the <EXECUTE> key. Screen prompts will appear directing the installation of the IREPS program. After installation is complete, the IREPS program may be executed by typing LOAD "IREPS",1 and pressing the <EXECUTE> key.

Warning! The installation program provided by NOSC is custom tailored for an individual user and machine. For this reason, IREPS 3.0 may not be copied by a user and provided to other potential users. All requests for IREPS 3.0 must be made to NOSC at the above address.

4.1.1 Operator-Entered Data and the Floppy Diskette

All floppy diskettes used for storage of operator-entered data must be initialized external to the IREPS program. To initialize a floppy diskette, insert the diskette into the drive, type INITIALIZE ":INTERNAL" and press <EXECUTE>. Note! Care must be exercised to preclude the inadvertent initialization of the internal hard disk.

During the IREPS installation session, any data entered by the operator will be retained in the machine's memory. Upon closing the IREPS session, the operator will be queried for storage of this data. To preclude the inadvertent storage of classified data upon any non-securable hard disk, IREPS will default storage of operator-entered data to the internal floppy disk. At this time, the operator must insert a pre-initialized blank floppy diskette into the disk drive and respond to the storage prompt with <YES>, or the data will be lost when IREPS is exited. Refer to section 4.2.4.7 for a discussion of program defaults.

Subsequent IREPS sessions may be initiated by inserting the previously created operator-entered data floppy diskette into the drive, typing LOAD "IREPS",1 and pressing the <EXECUTE> key. The insertion of an initialized but blank diskette will generate a trapped program error. At this time, the operator will be prompted to exchange diskettes, reconfigure the system, or create the necessary memory files. As described above, at the session close, the operator-entered data will be written to the blank diskette.

An operator may require the use of many floppy diskettes, depending upon the amount of data needed for the IREPS session. A diskette may be exchanged any time the IREPS Option menu is displayed or when a screen prompt directs an exchange. Exchanging a diskette at other times will not physically damage the diskette but may cause the data to be unaccessible in the future.

4.1.2 Key Definitions

The first screen display that appears after starting the IREPS program is shown in figure 4-1. These are the definitions assigned by the IREPS program to the special function keys in the upper right of the keyboard. The operator can use these keys to control program operation and screen display. For convenience, the definitions may be abbreviated and written on a special function-key overlay provided with the computer. The key definitions are mostly self-explanatory and their use will become clearer as the operator gains familiarity with the IREPS program. The screen display is followed by a prompt to press <RETURN> to continue with the program.

```
>> INTEGRATED REFRACTIVE EFFECTS PREDICTION SYSTEM <<

IREPS PROTECTED UNDER UNITED STATES PATENT 4,125,893

The following keys will be in effect unless otherwise noted:
    KEY 'k0' will back up to the previous question.
    KEY 'k2' will turn the alpha screen on and graphics off.
    KEY 'k3' will turn the graphics screen on
        ( shift 'k3' will turn the alpha screen off)
    KEY 'k4' will disable internal printer.
    KEY 'k5' will enable internal printer.
    KEY 'k16' (shift 'k0') will toggle ENGLISH/NUMERIC units
        ( Used for keyboard entry ONLY)

Pressing <RETURN> with no other entry will assign the first option in
    parentheses (or the first option in the list) as the desired option.
```

Figure 4-1. Special-function key definitions.

Of particular note is KEY 'k16'. Whenever a screen prompt requests an input of data from the operator, the units of the input value may be toggled between English and metric with this key. For example, if the prompt requests a height in feet and the operator desires to enter the height in meters, pressing KEY 'k16' will change the prompt to ask for the height in meters. Once changed with KEY 'k16', the units will remain constant until the key is pressed again. Use of KEY 'k16' will have no effect upon the units of the output product.

4.2 IREPS OPTIONS

Following the pressing of <RETURN> from the special function keys screen display, a list of IREPS options will be displayed. This option list is illustrated in figure 4-2. These options are used to obtain an IREPS product or perform a major function. Normally, the first step in using IREPS to assess refractive effects is to provide environmental data to the program (by selecting option 1). Selecting an environmental data set prior to using the UTILITIES option is not required, however.

```
Current environment: - - - No data set specified - - -

IREPS OPTIONS:
     1.  INPUT ENVIRONMENTAL DATA SET
     2.  PROPAGATION CONDITIONS SUMMARY
     3.  COVERAGE DISPLAY
     4.  LOSS DISPLAY
     5.  AEW STATIONING AID
     6.  SURFACE-SEARCH RADAR-RANGE TABLE
     7.  ESM INTERCEPT RANGE TABLE
     8.  FLIR PERFORMANCE RANGE SUMMARY
     9.  RUN AUTO-MODE
    10.  UTILITIES

Enter IREPS option (or END) (1 to 10)
```

Figure 4-2. Screen display of the IREPS options.

4.2.1 IREPS Option 1 - Input Environmental Data Set

By selecting IREPS option 1, the previously entered environmental data sets (if any) will be displayed. Figure 4-3 illustrates the format for this display.

```
Current environment: --- No data set specified ---

Available environmental data sets:

                    Date/Time            Location

PROTECTED 1         23 Oct 86 1200Z      SOCAL OPAREA
PROTECTED 2         STANDARD             0 KNOTS WIND
PROTECTED 3         YEARLY day/night     33 10N   120 30W
          4         USS America          Indian Ocean


Number of environmental data set desired (or NEW) (1 to 4)
```

Figure 4-3. Screen display showing existing environmental data sets

The operator must select the desired data set number (1 to 16 possible) or NEW (to input new data) and then press the <RETURN> key. Selecting a number (1 through 16) will cause the appropriate data set to be entered into the program and the operator will be returned to the IREPS option menu. Selecting NEW will present the data type menu as illustrated in figure 4-4.

As subsequent new data sets are entered, each data set in the file is moved up one position, with the lowest-numbered unprotected data set being deleted. Protection of a data set prevents its automatic deletion. Data sets are normally unprotected, with only those the operator considers unique or significant enough to retain for later use being protected. If the operator desires, data sets in excess of 16 may be stored on additional user data floppy diskettes. After the entry of an environmental data set, the operator will be returned to the input options menu for additional inputs or for return to the IREPS options menu.

```
Current environment: - - - No data set specified - - -

INPUT OPTIONS:
     1   RSONDE (Press,Temp,RH)
     2   M UNITS (Height, M units)
     3   N UNITS (Height, N units)
     4   WMO CODE
     5   HISTORICAL
     6   REFRACTOMETER


Enter INPUT option (or END) (1 to 6)
```

Figure 4-4. Screen display showing types of environmental data.

4.2.1.1 Surface Entries for NEW Option. For all NEW options except HISTORICAL, a series of questions are asked that require inputs of surface meteorological conditions. These entries are prompted in the form:

(1) Wind speed - True wind speed between 0 and 50 knots.

(2) Evaporation duct height source - If PARAMETERS is selected, the evaporation duct height will be calculated from the operator inputs of air temperature, sea-surface temperature, relative humidity, and wind speed. If SPECIFIED is selected, the operator may enter a value for the duct height. If UNKNOWN is selected, the evaporation duct height will be set to 13 meters, a worldwide average evaporation duct height.

(3) Sea-surface temperature - The temperature at the sea surface is best measured with an accurate thermometer and a small bucket that has been lowered into water undisturbed by the ship's wake. Satisfactory measurements are also obtainable by using the surface temperature from an expendable bathythermograph (XBT) if the XBT is not launched into the wake. Injection water temperature measurements are generally very

inaccurate for the purpose required here and should be avoided if at all possible. Sea temperature must be between 0 and 40 degrees Celsius. If the evaporation duct height source is SPECIFIED or UNKNOWN, sea temperature will not be requested.

(4) Surface air temperature - Must be between -20 and 50 degrees Celsius and is best measured with a hand-held psychrometer at any location above 6 meters (20 feet). Care should be taken to minimize any ship-induced effects such as heating from exhausts vents, radiating surfaces, etc.

(5) Surface relative humidity - Best measured along with the air temperature as described above. Humidity must be between 0 and 100 percent.

(6) Visibility - Standard visibility measurement. If the visibility is unknown, select the default option which sets the visibility to unknown.

4.2.1.2 Radiosonde (RSONDE). A response of 1 to the type of data input prompt will indicate that radiosonde data are to be entered. The program will sequentially present the prompts shown in figure 4-5. (Sample responses to the prompts are shown in the second line of each set.) The input data are as follows.

(1) Units of height (feet or meters) - The units to be used on the PROPAGATION CONDITION SUMMARY product.

(2) Location - Any 18 characters the operator chooses, generally the latitude and longitude of the radiosonde sounding. The default value is NOT SPECIFIED.

(3) Date/Time - Any 18 characters the operator chooses, generally the time of the radiosonde launch. The default value is NOT SPECIFIED.

(4) Surface entries as described above.

(5) Radiosonde launch height - Height at which the radiosonde is released. This height must be between 0 and 300 meters (0 to 1000 feet).

(6) Station pressure at launch height - The station pressure corrected to the radiosonde launch height. This is also the pressure of the surface level of the sounding. Station pressure must be between 900 and 1100 millibars.

The sounding data are then entered sequentially as pressure, temperature, and relative humidity at each significant level, beginning with the first level above the launch height. Pressures must be in decreasing order, with additional data restrictions as defined above. For temperatures less than -40 degrees Celsius at which relative humidity is not observed, enter 19 for relative humidity. Normally, only data up to approximately 6300 meters (20,000 feet) (500 mb) are required since almost all significant refractive effects occur below this altitude. For this reason, data are restricted to only 29 significant levels.

After all levels have been entered, the operator is asked if the data set should be protected. Normally it is not desired so the default value is set to NO.

Units of height (FEET, METERS)
F

Location
23 10 N 061 17E

Date/Time
2235Z 23 Oct 86

Wind speed in knots (0 to 50)
10

Visibility in nautical miles (0 means unknown)
12

Evaporation duct height source (PARAMETERS, UNKNOWN, SPECIFIED)
P

Sea temperature in degrees C (0 to 40)
25.8

Surface air temperature in degrees C (-20 to 50)
25.6

Surface relative humidity in percent (0 to 100)
77

Radiosonde launch height above msl in feet (0 to 1000)
30

Station pressure at launch height in mb (900 to 1100)
1009.2

Enter Pressure(mb), Air temp(C), RH(%) for level 2
1000,25.2,44

Enter Pressure(mb), Air temp(C), RH(%) for level 3
986,26.4,32

.
.
.

Enter Pressure(mb), Air temp(C), RH(%) for level 16 (or END)
400,-21.6,69

Enter Pressure(mb), Air temp(C), RH(%) for level 17 (or END)
END

Figure 4-5. Radiosonde data input sample.

4.2.1.3 M–Units. A response of 2 to the type of data prompt will indicate that modified refractivity data are to be entered. The program will sequentially present the prompts shown in figure 4-6. Units, location, date/time, wind speed, visibility, evaporation duct, sea and air temperature, and relative humidity are discussed in the preceding section. Height offset from mean sea level is the initial height to which all subsequent heights are referenced. This height is normally zero. An example of a nonzero offset would be data from a refractometer-equipped aircraft in which the heights of the profile are computed as height above launch height. The height offset in this case would be the height of the refractometer above sea level at the time of aircraft launch.

The profile data are then entered sequentially as height and M units. Heights must be increasing and M-units must be between 50 and 1500 units.

4.2.1.4 N Units. A response of 3 to the type of data prompt will indicate that refractivity data are to be entered. N-unit data entry is similar to that of M-unit data described in section 4.2.1.3. The range of allowable N-units is 50 to 450.

4.2.1.5 WMO Code. A response of 4 to the type of data prompt will indicate that coded radiosonde data are to be entered. The program will sequentially present the prompts shown in figure 4-7. Location, date/time, wind speed, visibility, evaporation duct, sea and air temperature, relative humidity, and radiosonde launch height are discussed in the preceding section. Launch heights can be obtained from the WMO Station Index, or, in the case of ships, estimated.

The profile data are the significant level code groups of Part B of the coded message. (It has been found that mandatory levels, Part A, may also be significant but have been deleted from part B. For this reason, it may be advantageous to merge parts A and B if there are fewer than 29 levels). The code groups must be in the form "nnPPP TTTDD", where

nn is the significant level indicator number
PPP is the pressure in millibars
TTT is the air temperature in degrees Celsius
DD is the dew point depression in degrees Celsius

The program indicates the significant level number for the level to be entered, and the bars in the display correspond to the length of the code group.

Units of height (FEET, METERS)
F

Location
23 10 N   061 17E

Date/Time
2235Z 23 Oct 86

Wind speed in knots (0 to 50)
10

Visibility in nautical miles (0) means unknown)
12

Evaporation duct height source (PARAMETERS, UNKNOWN, SPECIFIED)
P

Sea temperature in degrees C (0 to 40)
25.8

Surface air temperature in degrees C (-20 to 50)
25.6

Surface relative humidity in percent (0 to 100)
77

Height offset from msl in feet (0 to 1000)
0

Enter HEIGHT in feet and M-UNITS for level 1
30,370

Enter HEIGHT in feet and M-UNITS for level 3
295,334

.
.
.

Enter HEIGHT in feet and M-UNITS for level 16 (or END)
22475,1299

Enter HEIGHT in feet and M-UNITS for level 17 (or END)
END

Figure 4-6. M-unit data input sample.

Units of height (FEET, METERS)
M

Location
23 10 N   061 17E

Date/Time
2235Z 23 Oct 86

Wind speed in knots (0 to 50)
10

Visibility in nautical miles (0 means unknown)
12

Evaporation duct height source (PARAMETERS,UNKNOWN,SPECIFIED)
P

Sea temperature in degrees C (0 to 40)
25.8

Surface air temperature in degrees C (-20 to 50)
25.6

Surface relative humidity in percent (0 to 100)
77

Radiosonde launch height above msl in meters (0 to 300)
9

ENTER CODE GROUPS for level 1
00009 25643

ENTER CODE GROUPS for level 2
11000 25263

.
.
.

ENTER CODE GROUPS for level 16 (or END)
66400 21714

ENTER CODE GROUPS for level 17 (or END)
77END

Figure 4-7. WMO coded data input sample.

4.2.1.6 Historical. In cases where no current environmental data are available or a planner desires example IREPS products for a future operation, a climatology of refractive conditions may be accessed to create an N-unit profile suitable for entry into the IREPS program. This is accomplished by responding with a 5 to the type of data prompt. The operator will then be prompted for entry of a latitude and longitude for the desired location. The entries are input in degrees, minutes (optional), and a hemisphere indicator. Valid indicators are N and S (north and south) for latitude and W and E (west and east) for longitude. Latitude values may vary between 0 and 90 degrees, while longitude values may vary between 0 and 180 degrees. Should the minutes entry be desired, the entry must be between 0 and 59 with a blank space entered between the degrees and minutes. A blank space between the minutes and the hemisphere indicator is not necessary.

The operator will be presented with a series of menus, as illustrated in figure 4-8, which will prompt for time period and profile type. Profiles over a trimonthly period or a yearly average may be obtained. In some cases, only one type of ducting environment is of interest. For example, the Historical Propagations Conditions Summary may indicate an elevated duct occurs 65 percent of the time, while a surface-based duct may occur only 5 percent of the time, and, thus, a "typical" environment may be best represented by only an elevated duct profile. Once the desired profile type is selected, it will be written to the user environmental-data library and tagged with the location, season, and time of day to facilitate reference.

Refractivity profiles constructed from the climatological data base are referenced to msl; however, the profile information contained within the database is referenced to the station height. Therefore, a generated refractivity profile containing a surface duct may translate the surface duct to an elevated duct when it is referenced to msl. It will always be a surface duct at the station height. If a surface duct is critical and this translation effect occurs, then the profile must be edited using the Edit User Data Files utility described in section 4.2.4.2.

NOTE! IREPS products generated from climatology should be tagged in the user's comment lines as such. In addition, the percent occurrence of the profile should also be noted.

Periods:
1 JAN-MAR
2 APR-JUN
3 JUL-SEP
4 OCT-DEC
5 YEARLY

Period:

Time of day:
1 DAY
2 NIGHT
3 DAY AND NIGHT

Time of day:

TYPES OF PROFILES:
1 STANDARD
2 SURFACE-BASED DUCT ONLY
3 ELEVATED DUCT ONLY
4 COMBINED SURFACE BASED AND ELEVATED DUCTS
5 NO PROFILE

Number of type of profile:

Data set to be protected (NO,YES)

Figure 4-8. Historical-data input sample.

4.2.1.7 Refractometer. A source of environmental data is the AN/AMH-3 Electronic Refractometer Set, also known as an Airborne Microwave Refractometer (AMR). This device is mounted on an aircraft and directly measures the refractivity. When activated, the unit records static pressure, Pitot pressure, air temperature, and refractivity every 1.7 seconds and stores the data on a magnetic cassette for post-flight processing.

The reduction of the refractometer data tape within the IREPS program is a complicated process. It relies on specialized hardware and certain operator skills. The following descriptions assume that the hardware is set up according to the instructions found in section 5.1 and that the operator is familiar with the analysis guidelines of section 5.3

Analysis of the data recorded by the AN/AMH-3 is selected by responding with an entry of 6 to the type of data prompt under the NEW option of the Input Environmental-Data-Set option. This is a two-step process. First, the data are

transferred from the magnetic cassette tape to a disk or memory volume file maintained by the IREPS program. The transfer, or read, process typically takes approximately 7 minutes of computer time to complete. During the read process, the operator is generally not required to intervene unless an abnormal condition is found. On the HP520 computer, the operator is freed to perform other IREPS functions (but must not terminate) while the cassette is being read. The second step in the data analysis requires direct operator assistance. In this step, the data from the disk or memory volume file are read by the program (this occurs very fast), graphically displayed, and the operator is prompted to select or digitize portions of the data for inclusion into the IREPS Environmental Data Set.

The refractometer option list is shown in figure 4-9.

```
REFRACTOMETER OPTIONS:
  1 - Transfer data from cassette to memory
  2 - Retrieve data from memory


Refrac option (or END) (1 to 2)
```

Figure 4-9. Refractometer option list.

Transfer data from cassette option. A response of 1 to the refractometer option prompt requests the start of reading data from an AN/AMH-3 data tape to an internal disk or memory volume file. It is assumed that the hardware is correctly configured (section 5.1), and operational (section 5.2). Hardware and/or software errors encountered in this phase are reported to the operator, who may then refer to section 5.2 for recovery or diagnostic procedures.

The operator enters an identification of the data tape at the prompt

Enter Identification Label:

This label is stored with the data read from the cassette and is used only as an identifier of the specific data tape. The label is defaulted to the current date and time; however, it is recommended that the operator enter a label consisting of the aircraft number followed by the date and time of the actual flight. Up to 24 characters may be entered.

A typical data cassette contains approximately 10,000 samples of height and refractivity and requires approximately 7 minutes to read. During the read process, the following status messages may be displayed:

```
PLEASE POWER ON THE M-80 TAPE READER
PLEASE INSERT TAPE INTO M-80 READER
REWINDING M-80
LOADING TAPE FORWARD
REFRACTOMETER TIME hr:mi:se
END OF TAPE
```

These messages are self-explanatory. Additional details may be found in section 5.2.

Any errors reported on the display are also recorded into the data file for review with Refrac Option 2. If any errors are reported, the IREPS program should be normally terminated and the diagnostic procedures described in section 5.2 followed. Under normal circumstances, the read process overwrites the previous contents of the data file (REFRAC) with the data from the current tape. Only one file is maintained. Termination of the read phase, either normally or abnormally, is indicated by a distinctive sounding of the computer's audio speaker (bell).

Retrieve data from memory. A response of 2 to the refractometer prompt allows the operator to analyze the data stored in the disk or memory volume file. This procedure prompts the operator to (1) examine the height of the aircraft during the entire flight (height profile); (2) select portions of the height profile to analyze the refractivity as a function of height (refractivity profile); and (3) store the refractivity profile into the Environmental-Data Set for later use by the IREPS Products.

The operator is requested to enter inputs for the evaporation duct height, wind speed, and visibility as described in section 4.2.1.1. These values will be included with the refractivity profile that is built from the refractometer data.

The instructions for selecting a time segment from the aircraft's height profile are presented as in figure 4-10. Figure 4-11 shows a typical height profile. Generally, that last descent of the aircraft is selected; however, there are no restrictions other than the starting time must be less than the ending time and the ending time cannot exceed the last time displayed. After the time segment of interest has been selected, the type of refractivity units to plot as a function of height is requested by the prompt

Type of units (N-units,M-units)

A guide to the selection of the type of units is provided in section 5.3.

Retrieve a section of the refractometer data by the following:

1. Align CROSS HAIR with the desired starting time.
2. Press <RETURN>.
3. Align CROSS HAIR with the desired end time.
4. Press <RETURN>.

Use the display arrow keys to align the CROSS HAIR. A coarse movement is obtained by simply pressing the arrow key that points in the direction you want the CROSS HAIR to move. A fine movement is obtained by holding down the SHIFT key and pressing the arrow key.

The refractivity data within the times selected will then be plotted versus height.

Figure 4-10. Height-profile selection instructions.

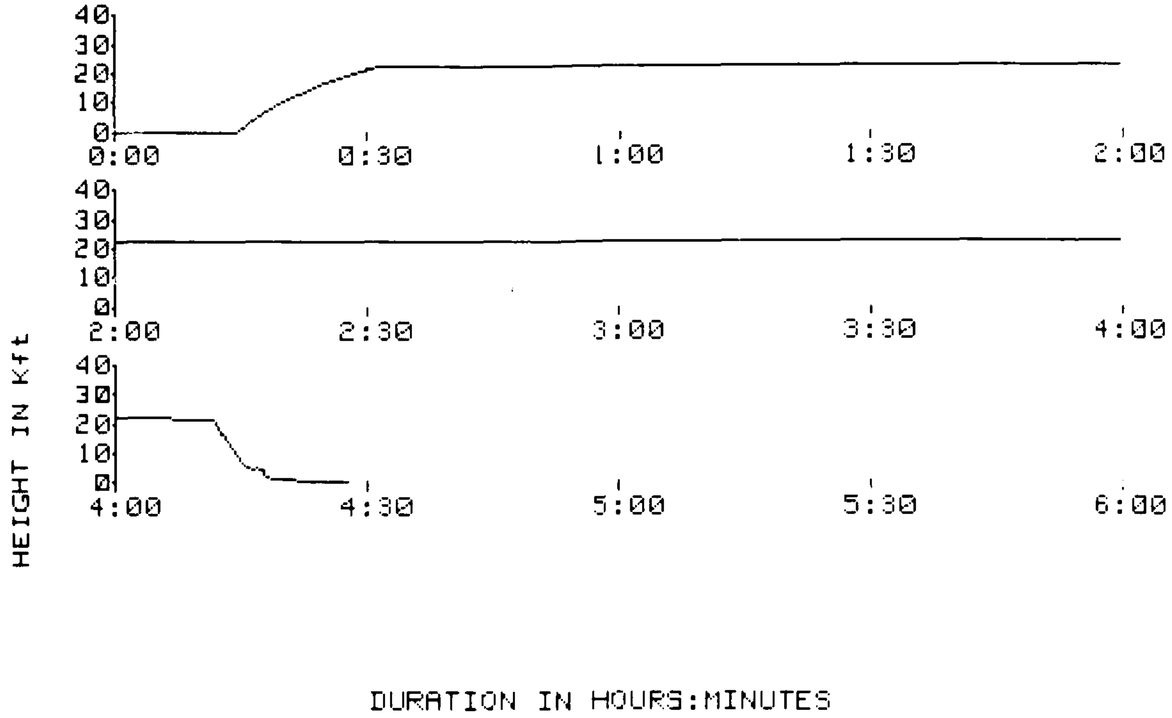


Figure 4-11. Aircraft's height versus time (height profile) display.

Figure 4-12 is the refractivity profile for the time segment starting at 4:4:35 and ending at 4:29:47 of figure 4-11. The values of height and refractivity pairs are manually selected or digitized from this display by the operator using the cursor and arrow keys. It is strongly recommended that the operator be familiar with the Refractometer Data Analysis Guidelines of section 5.3. Figure 4-13 shows the complete analyzed profile; a maximum of 29 height and refractivity pairs, or levels, may be entered.

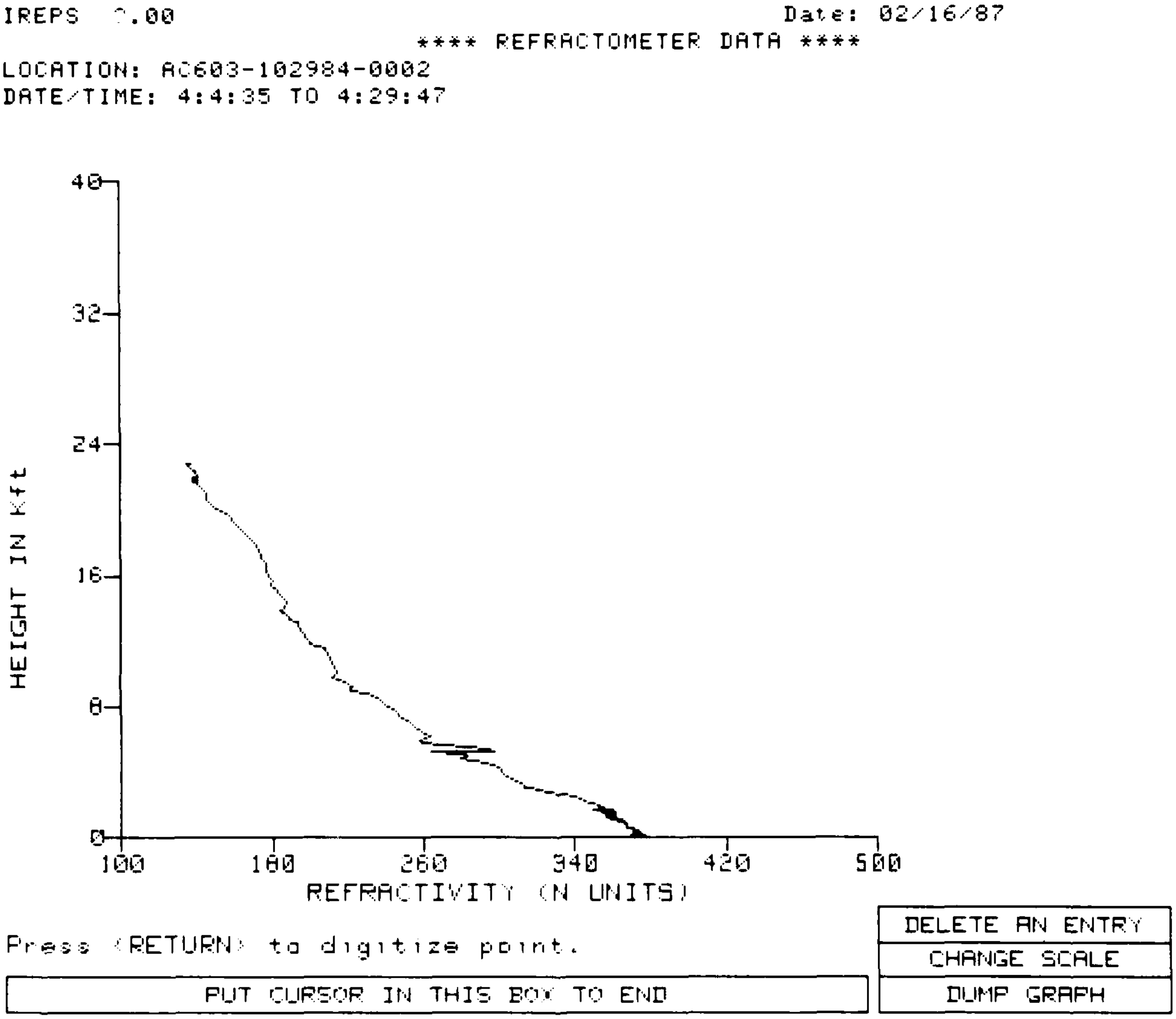


Figure 4-12. Refractometer refractivity-profile display.

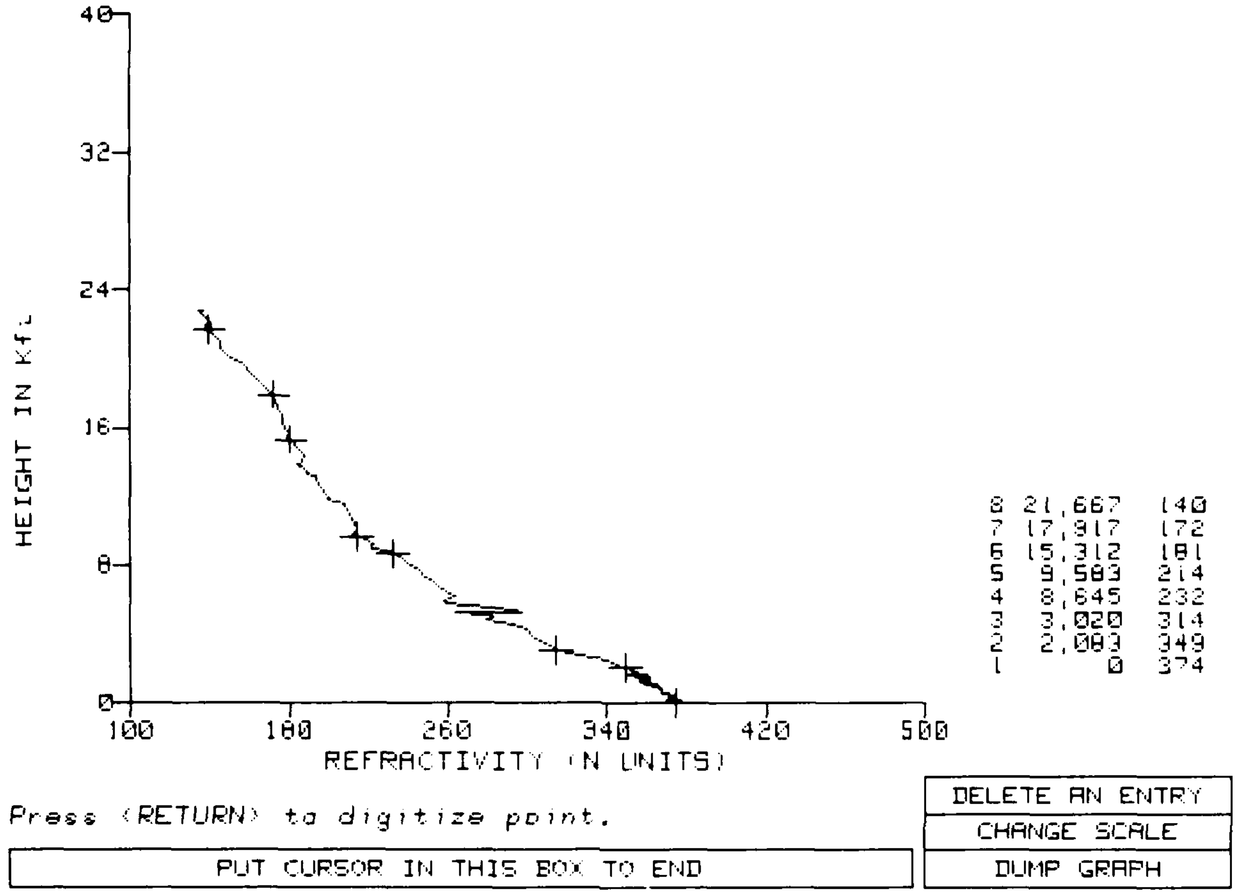


Figure 4-13. Analyzed refractometer refractivity-profile display.

Prior to storage into the Environmental Data Set, the digitized profile is displayed to the operator for a final verification of the data as shown in figure 4-14. An affirmative (default) response to the Profile OK prompt automatically stores the profile into the Environmental Data Set.

```
 8  Levels input
Level Height(ft)   M UNITS    N UNITS
  1          0.0     374.3      374.3
  2       2082.7     448.7      349.1
  3       3020.3     458.7      314.2
  4       8645.4     646.1      232.5
  5       9583.0     672.9      214.4
  6      15312.3     913.3      180.8
  7      17916.6    1029.5      172.4
  8      21666.7    1176.5      139.9




Profile OK (YES,NO)
```

Figure 4-14. Refractometer refractivity-profile list and verification display.

4.2.2 IREPS Options 2 through 8

The selection of IREPS options 2 through 8 will produce the various products as described within section 3.1. Various products will require an operator interactive session during the time of actual product generation. For example, IREPS option 4 (Loss Display), will require the operator to enter a receiver or target height. Screen prompts will be provided as necessary to complete the product request. At the completion of each requested product, the operator will be presented with the IREPS option menu for additional product selection, performance of utility functions or program termination.

4.2.3 IREPS Option 9 - Run Automode

The selection of IREPS option 9 will produce an automatic (hands off) generation of any and all (with multiple copies) IREPS products. The generation is made using a recipe previously specified by the operator. A detailed discussion of this specification process may be found in section 4.2.4.2. This option becomes useful once the routine users of IREPS products, and the types of products they utilize, have been established. In addition to any IREPS product, a listing of the current environmental data (Utilities option 3 - List Current Environmental Data) may be accomplished under the automode option.

4.2.4 IREPS Option 10 - Utilities

Selection of IREPS option 10 will access the utility function menu as illustrated in figure 4-15.

```
Current environment: - - - No data set specified - - -

    UTILITY OPTIONS:

     1  LIST USER DATA FILES.
     2  EDIT USER DATA FILES.
     3  LIST CURRENT ENVIRONMENTAL DATA.
     4  LIST HISTORICAL ENVIRONMENTAL DATA.
     5  RADAR FREE SPACE DETECTION RANGE CALCULATIONS.
     6  FREE SPACE INTERCEPT RANGE CALCULATIONS.
     7  SURFACE REFRACTIVE CONDITIONS.
     8  RECONFIGURE IREPS PROGRAM.

Enter UTIL option (or END) (1 to 8)
```

Figure 4-15. IREPS utility function menu.

User data are defined as data entered by the operator of the IREPS program. User data consist of electromagnetic system parameters such as frequency and transmitter height, environmental parameters such as atmospheric pressure and wind speed, and recipes created for program direction. Initial entry, display, editing, or deletion of previously entered user data is accomplished through the use of the list or edit utilities.

4.2.4.1 Utility option 1 - List user data files. This listing utility may be used to obtain a paper copy of any user data for archival or transfer purposes. For example, should an unresolved software problem within the IREPS code be discovered by an operator, the user data involved in the error may be forwarded to NOSC to aid in software trouble shooting.

4.2.4.2 Utility option 2 - Edit user data files. The editing utility serves as the user data input, alteration or deletion point for the IREPS program. Upon selecting utility option 2, the various user data types are displayed as illustrated in figure 4-16.

```
Current environment: - - - No data set specified - - -

EDIT OPTIONS:
   1  ENVIRONMENTAL DATA SETS
   2  COVERAGE SYSTEMS
   3  LOSS SYSTEMS
   4  RADAR FREE SPACE RANGE SYSTEMS
   5  SURFACE SEARCH SYSTEMS
   6  ESM RECEIVER SYSTEMS
   7  ESM EMITTER SYSTEMS
   8  FLIR SYSTEMS
   9  AUTOMODE SYSTEMS

Enter EDIT option (or END) (1 to 9)
```

Figure 4-16. Edit options screen display.

The following discussion applies equally to all systems, 1 through 9. Selection of a system category will produce a screen listing of the various systems within the category. The operator will then be prompted to either ADD, CHANGE, DELETE a system or END the editing function. Figure 4-17 is an illustration of the screen display format for edit option 2, coverage systems.

```
EXISTING COVERAGE SYSTEMS
    1  surface search radar        2  specific
    3  generic height finder       4  uhf comms
    5  airborne radar              6  unnamed
    7  system-xx

Next option: (END,ADD,CHANGE,DELETE): (E,A,C,D)
```

Figure 4-17. Example of existing coverage system.

The ADD option allows the operator to input parameters for a system. Screen prompts will query the operator for the necessary system or environmental parameters. The environmental input parameters are described in section 4.2.1. The parameters for electromagnetic and electro-optic systems are described in section 4.3. IREPS places limits on the maximum number of systems, within each system type, which may be stored on one user data floppy diskette. These limits are 16 environments; 32 cover, loss, radar free-space range, surface search, ESM receiver, and FLIR systems; 5 libraries of ESM emitter systems with up to 60 emitters within each library; and 4 automode recipes. If the maximum number of systems within any one system type currently exists on the floppy diskette, the ADD option will be unavailable for that system type. At this point, the operator must either delete one of the current systems or substitute another user-data floppy diskette.

Of particular note is the AUTOMODE system. When the operator selects the ADD option for an AUTOMODE system, a listing of IREPS products will be displayed on the screen. Upon the selection of an IREPS product, screen prompts will query the operator for additional system parameters. If an additional copy of any product be desired, it must be entered as a separate product. Approximately 40 products may be contained within one AUTOMODE recipe. When an AUTOMODE recipe is created, that recipe will apply only to systems on that particular floppy diskette and only as they appear on the floppy diskette at the time of recipe creation. AUTOMODE recipes consist of internal pointers which point to particular locations upon the floppy diskette. Should a system be deleted from the diskette and a new system substituted in its spot, the new system will be used when the AUTOMODE option is requested. For this reason, whenever there is a deletion of a system which is employed within an AUTOMODE recipe, a new AUTOMODE recipe should be created.

The CHANGE option will produce a screen listing of the various parameters associated with the system and a prompt for a parameter number. Selection of a number will produce a prompt for the parameter's new value.

The DELETE option will produce a prompt for the number of the system to deleted. Multiple deletions can be accomplished by separating numbers with a comma or by typing a start number, a dash, and an end number. For example, to delete items 3 through 7, respond to the prompt by typing <3-7>.

The END option will return the operator to the editing menu of figure 4-16.

4.2.4.3 Utility option 3 - List current environmental data. Assuming an environmental-data set has been previously selected by the operator, selecting utility option 3 will produce a listing of this environmental data (figure 4-18). This listing is used primarily for checking numerical values entered from IREPS option 1 (input environmental data). This listing may also serve as an archive for environmental-data sets for future use. In addition to displaying the data input by the operator (i.e., pressure, temperature, M-units, etc.), values of dew-point depression, N-units gradients, and refractive conditions are calculated and displayed. If the original data were input via WMO code, the phrase "derived from WMO code" will appear immediately below the listing title. The bottom line of the list also displays the surface refractive conditions and the setting for the SPS-48 height-finder radar to properly account for refractive effects in its calculations of elevation angle and height.

IREPS 3.00 Date: 02/16/87

**** ENVIRONMENTAL DATA SET ****

LOCATION: AREA 2
DATE/TIME: MARCH 3, 1987 - 12

WIND SPEED 3.0 meters per second DEFAULT EVAP DUCT HEIGHT= 13.0 meters
VISIBILITY 12.9 kilometers

RADIOSONDE LAUNCH HEIGHT = 9.7 METERS

LEVEL	PRESS (mB)	TEMP (C)	RH (%)	DEW PT DEP(C)	METERS	N UNITS	N/Kft	M UNITS	CONDITION
1	1,013.9	19.3	41.0	13.7	9.7	309.1	-20.0	310.6	NORMAL
2	1,000.0	17.4	39.0	14.2	127.9	301.4	-6.7	321.4	NORMAL
3	917.0	11.3	57.0	8.2	859.9	285.4	-27.0	420.3	SUPER
4	875.0	9.1	19.0	30.0	1,249.8	250.8	11.7	447.0	SUB
5	850.0	7.5	51.0	9.5	1,489.2	260.0	17.8	493.8	SUB
6	833.0	5.8	86.0	2.2	1,655.2	269.7	-10.1	529.5	NORMAL
7	763.0	-1.0	100.0	0.0	2,366.0	246.1	-33.1	617.5	SUPER
8	754.0	-.1	71.0	4.6	2,461.0	235.8	-31.7	622.1	SUPER
9	734.0	3.1	19.0	30.0	2,677.6	213.2	-7.2	633.5	NORMAL
10	700.0	1.5	19.0	30.0	3,060.5	204.1	-7.3	684.5	NORMAL
11	677.0	1.2	19.0	30.0	3,329.3	197.7	-6.2	720.3	NORMAL
12	587.0	-7.4	19.0	30.0	4,458.3	174.9	-5.2	874.7	NORMAL
13	555.0	-12.3	19.0	30.0	4,890.8	167.5	-5.3	935.2	NORMAL
14	400.0	-22.2	19.0	30.0	7,346.3	124.8	------	1,277.9	------

SURFACE REFRACTIVITY: 310 --SET SPS-48 TO 313

Figure 4-18. Environmental data list.

4.2.4.4 Utility option 4 - List historical environment. Often times, an operations planner may desire general information about the environmental conditions of an area. A climatological summary of the refractive conditions for coastal and ocean areas of the world is contained with the IREPS program. By specifying a latitude and longitude, the operator is able to recall and display this climatological environmental data.

The operator will be prompted for entry of a latitude and longitude for the desired location. The entries are input in degrees, minutes (optional), and a hemisphere indicator. Valid indicators are N and S (north and south) for latitude and W and E (west and east) for longitude. Latitude values may vary between 0 and 90 degrees while longitude values may vary between 0 and 180 degrees. Should the minutes entry be desired, the entry must be between 0 and 59 with a blank space entered between the degrees and minutes. A blank space between the minutes and the hemisphere indicator is not necessary.

Figure 4-19 is an example of this historical propagation conditions summary. The main body of the summary consists of five tabular listings, each of which are separated into yearly and trimonthly categories. These categories are further divided into daytime, nighttime, and the combination of both day and night. An asterisk within the body of the table indicates sufficient statistical data are unavailable.

The first table presented by the historical program is entitled PERCENT OCCURRENCE OF ENHANCED SURFACE-TO-SURFACE RADAR/ESM/COM RANGES. The statistics indicate, as a function of frequency, the percentage of time surface-to-surface propagation will exceed the range predicted under standard atmospheric conditions. The next two tables provide data on the percent occurrence and geometry of surface-based and elevated ducts. Following these is a distribution of the evaporation duct height showing the percent of time a range of heights is found and the mean duct height for the period of interest. The last table lists data of general use, such as the percentage of time an elevated duct and a surface-based duct jointly occur.

4.2.4.5 Utility options 5 and 6 - Free-space detection/intercept range calculations. The free-space detection (for radar systems) or intercept (for ESM or communications systems) range is defined as the range at which a system can detect, communicate or intercept a signal outside the influence of the earth's atmosphere (in free space). An analogous term is free-space path loss, which is defined as the maximum energy loss (in free space) that can be sustained and still have sufficient energy for detection or intercept. The free-space range (or path loss) is the most important parameter in properly assessing any system's performance. It may be considered as a "figure of merit" for the subject system and, as such, special care must be exercised in determining the free-space range (or path loss) for each application, or the resulting IREPS product could be misleading.

Establishing the free-space range for radar detection. Often, the most accurate method of establishing the free-space range is by observation of the actual maximum detection range of known targets at angles above a few degrees from the horizontal, where effects of refraction are minimized. In the case of surface-based 2D air-search radar systems, the free-space detection range is one-half the maximum observed range because of the influences of the interference region. For surface-based height-finder and all airborne radar systems, the free-space detection range is the maximum observed range.

If actual observations are not available, a theoretical calculation can be made by using the radar free-space detection range-calculation utility. This utility will also provide the free-space path loss value. The following parameters must be specified by the operator:

IREPS 3.00 HISTORICAL EM PROPAGATION CONDITIONS SUMMARY

Specified location: 32 00 N 117 00 W (*) INDICATES INSUFFICIENT DATA
Radiosonde source : 72290 32 49 N 117 08 W
Radiosonde station height: 407 Feet
Surface obs source: MS120 35 00 N 115 00 W

PERCENT OCCURRENCE OF ENHANCED SURFACE-TO-SURFACE RADAR ESM COM RANGES:

FREQUENCY	YEARLY			JAN-MAR			APR-JUN			JUL-SEP			OCT-DEC		
	day	nit	d&n	day	nit	d&n	day	nit	d&n	day	nit	d&n	day	nit	d&n
100 MHz	3	3	3	2	3	3	3	2	2	5	3	4	3	4	3
1 GHz	37	21	29	37	24	30	31	13	22	40	21	31	39	25	32
3 GHz	43	26	35	43	30	37	38	17	27	47	26	36	46	32	39
6 GHz	56	37	47	55	42	49	52	29	40	58	34	46	60	44	52
10 GHz	77	65	71	73	65	69	76	62	69	80	64	72	80	69	75
20 GHz	87	83	85	84	81	83	87	82	85	89	82	86	89	85	87

SURFACE BASED DUCT SUMMARY:

PARAMETER	YEARLY			JAN-MAR			APR-JUN			JUL-SEP			OCT-DEC		
	day	nit	d&n	day	nit	d&n	day	nit	d&n	day	nit	d&n	day	nit	d&n
Percent occurrence	25	22	23	18	26	22	24	15	20	33	21	27	23	27	25
AVG thickness Kft			.44			.29			.40			.70			.39
AVG trap freq GHz			.89			.96			1.4			.55			.78
AVG lyr grd -N Kft			91			88			90			94			93

ELEVATED DUCT SUMMARY:

PARAMETER	YEARLY			JAN-MAR			APR-JUN			JUL-SEP			OCT-DEC		
	day	nit	d&n	day	nit	d&n	day	nit	d&n	day	nit	d&n	day	nit	d&n
Percent occurrence	42	54	48	28	38	33	47	65	56	56	72	64	37	41	39
AVG top ht Kft			2.5			2.7			2.6			2.2			2.6
AVG thickness Kft			.60			.47			.64			.78			.56
AVG trap freq GHz			.20			.30			.19			.11			.21
AVG lyr grd -N Kft			70			72			71			68			71
AVG lyr base Kft			2.2			2.5			2.2			1.7			2.3

EVAPORATION DUCT HISTOGRAM IN PERCENT OCCURRENCE:

PERCENT OCCURRENCE	YEARLY			JAN-MAR			APR-JUN			JUL-SEP			OCT-DEC		
	day	nit	d&n	day	nit	d&n	day	nit	d&n	day	nit	d&n	day	nit	d&n
0 to 10 Feet	9	9	9	10	10	10	9	8	9	9	10	10	8	8	9
10 to 20 Feet	8	13	10	9	15	12	7	12	10	7	12	10	7	12	10
20 to 30 Feet	13	22	17	13	21	17	14	20	17	13	23	18	11	20	15
30 to 40 Feet	15	22	18	11	18	15	17	25	21	18	24	21	14	20	17
40 to 50 Feet	11	12	12	9	11	10	12	13	13	13	12	12	10	13	12
50 to 60 Feet	7	6	7	6	6	6	8	7	8	7	5	6	8	7	8
60 to 70 Feet	4	3	4	4	3	4	4	3	3	4	3	3	5	3	4
70 to 80 Feet	3	1	2	3	2	2	3	1	2	3	1	2	3	2	2
80 to 90 Feet	2	1	1	2	1	2	2	1	1	2	1	1	3	1	2
90 to 100 Feet	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
above 100 Feet	27	10	19	30	12	21	23	7	15	24	9	17	30	12	21
Mean height Feet	74	45	60	79	48	63	69	41	55	69	43	56	81	50	65

GENERAL METEOROLOGY SUMMARY:

PARAMETER	YEARLY			JAN-MAR			APR-JUN			JUL-SEP			OCT-DEC		
	day	nit	d&n	day	nit	d&n	day	nit	d&n	day	nit	d&n	day	nit	d&n
# Accepted sndgs	414	405	410	403	395	399	417	405	411	409	419	414	423	400	414
% occur EL&SB dcts			4.4			3.2			4.7			6.9			3.4
% occur 2+ EL dcts			9.1			3.9			9.6			14			5.6
AVG station N			330			321			329			343			326
AVG station -N Kft			19			16			20			24			19
AVG sfc wind kts	10	11	10	10	11	10	11	12	1[illegible]	10	10	10	9.3	10	10

Figure 4-19. Historical propagation conditions summary.

Radar system parameters:

(1) transmitter frequency in megahertz
(2) transmitter peak power in kilowatts
(3) transmitter pulse length in microseconds
(4) transmitter pulse rate in pulses per second
(5) receiver noise figure in decibels
(6) transmitter antenna gain in decibels
(7) total system loss in decibels
(8) transmitter antenna horizontal beam width in degrees
(9) transmitter antenna horizontal scan rate in revolutions per minute
(10) for height finder radars, number of hits per scan

Target parameters:

(1) target radar cross section in square meters
(2) target type, either fluctuating or steady

Operator desired parameters:

(1) probability of detection in percent
(2) probability of false alarms

Establishing the free-space range for communications. The best approach for establishing a free-space communications range is by observation of maximum communication range at angles above a few degrees from the horizontal for surface-to-air or air-to-air communications. For the surface-to-air case, the free-space range is one-half the maximum observed communication range because of interference region effects. For the air-to-air case, the free-space range is equal to the maximum observed communication range. Often, uhf communications range is stated as "line of sight", but in reality there must also be a maximum range within the line of sight based on transmitted power, receiver sensitivity, and the signal-to-noise ratio required to successfully communicate. For most uhf communication systems, this range seems to be about 100 to 200 nmi.

Establishing the free-space range for ESM intercept. As with radar and communication ranges, the best method of determining a free-space ESM intercept range would be by actual observation. In reality however, an observed range would be very rare. Therefore a theoretical calculation may be made by using the free-space intercept range calculation utility. This utility requires the operator specify the following:

Transmitter system parameters:

(1) transmitter frequency in megahertz
(2) transmitter power in kilowatts
(3) transmitter antenna gain in decibels

ESM receiver parameters:

(1) sensitivity of receiver in decibels relative to a milliwatt

This free-space range can be extremely large, on the order of many thousands of nautical miles, which would truly be the ESM receiver's capability in free space. However, the influence of the earth and other factors discussed within this document eventually limit the actual intercept range to a value much less than the free-space intercept range. For this reason, the loss display is the proper IREPS product to use in assessing ESM intercept ranges when the free-space range calculated from the free-space intercept range utility is employed. The need to use the loss display to assess intercept ranges has been greatly reduced by the employment of the ESM intercept range table as described in section 3.1.6.

4.2.4.6 Utility option 7 - Surface refractive conditions. The surface refractive conditions utility is used when surface meteorological measurements are available but a radiosonde sounding is not. The utility will allow for the calculation of the evaporation duct height and the surface refractivity in N-units. In addition, this utility will determine the proper setting for the SPS-48 switch which compensates for the surface refractivity variations. The surface refractive conditions utility requires the operator specify the following:

(1) surface air temperature in degrees Celsius
(2) sea-surface temperature in degrees Celsius
(3) surface relative humidity in percent
(4) surface atmospheric pressure in millibars
(5) surface horizontal wind speed in knots

4.2.4.7 Utility option 8 - Reconfigure IREPS program. The reconfigure IREPS program utility is designed to allow the operator to specify the location of the various IREPS program and data files within the computer's various mass storage devices (i.e. internal or external hard disks, floppy diskettes or random access memory); to specify the device driver for the Memodyne tape reader; to specify the printer device number; and to specify the use of perforated or non perforated paper. An initial IREPS configuration has been defaulted by NOSC. It is recommended that this configuration not be modified by an operator other than the computer system manager.

Upon selection, the operator will be presented with a screen display similar to that of figure 4-20. The actual screen display will be a function of the customized installation program provided by NOSC to each individual user

```
Revision:  IREPS  3.00 hp9000                    Date:
Disk ID:    SN#
                                                              transfer
File set                   Directory path        Mass storage         to memory
--------------------------------------------------------------------------------
 1 IREPS Subroutines        /IREPS_3.0           internal hard disk
 2 User data files                               internal floppy disk     YES
 3 Historical files         /                    internal floppy disk     NO
 4 Refractometer data       /                    internal floppy disk     NO

 5 Device specifier for Memodyne tape reader: 3
 6 Printer device number: 6
 7 Perforated paper: YES
 8 Classification 0:
 9 Classification 1:
10 Classification 2:


Enter line to be changed (or END) (1 to 10)
```

Figure 4-20. Screen display for IREPS reconfigure utility.

Upon selection of lines 1 through 4, the operator will be prompted to respecify the directory path name and storage location for the IREPS program and the various data files. In the above example, the program and data reside on the floppy disk and upon program execution, the user data will be transferred into the computer memory. To conserve memory space, it is recommended historical and refractometer data not be loaded to memory upon program execution. The program will access the storage device as necessary.

Line 5 allows the the user to change the 'slot' position of the serial interface between the HP520 computer and the Memodyne M-80 tape reader. This is normally done only at one time when the tape reader is first installed. Refer to section 5 for details.

Line 6 specifies the printer to be the CRT or the internal paper printer, and line 7 allows for the use of either perforated or nonperforated paper.

IREPS allows the operator to classify user data at 3 different security levels. Lines 8 through 10 will define these security levels. The operator may enter up to 80 characters to represent the level. For example, classification 0 may be defined by the operator as "UNCLASSIFIED", "SECURITY LEVEL 3", "RESTRICTED", etc. It is the sole responsibility of the operator to adhere to the security requirements dictated by higher authority. Classification 0 is the default classification for all data entries.

4.3 SYSTEM PARAMETERS REQUIRED FROM OPERATOR

In order to generate an IREPS product, the operator must provide the program with various parameters for the electromagnetic or electro-optical system. These parameters describe the system and visual presentation of the displays. The operator is solely responsible for the determination of these parameters. For this reason, the operator is reminded that IREPS is designed to give relative performance assessments for various systems rather than an absolute performance value for a particular system. To assist in a standardization effort, NOSC maintains a limited library of system parameters, which is available upon request from any organization meeting the security requirements associated with the system.

4.3.1 Electromagnetic System Parameters

The following is a brief description of the various parameters required for electromagnetic systems:

(1) Platform type. There are two options for the type of platform, namely SURFACE or AIRBORNE. SURFACE platforms are primarily those associated with shipboard systems. However, a surface platform could be specified for any system with a transmitter between 3 and 250 feet above sea level. The primary difference between platforms is that calculations for the interference region are included for surface systems, but not for airborne systems.

(2) Antenna height. For surface-based systems, the antenna height above mean sea level may vary from 3 to 250 feet. For airborne systems, the antenna height may vary from 3 to 100,000 feet. For the coverage display, the antenna height may not exceed the maximum height of the display.

(3) Frequency. The limits upon system frequencies are 100 Megahertz to 20,000 Megahertz.

(4) Polarization. For both EM transmitters and ESM receivers, antenna polarizations are HORIZONTAL, VERTICAL, or CIRCULAR.

(5) Free-space detection/intercept range. Refer to section 4.2.4.5 for a discussion of these ranges and the parameters required for use of the calculation utility.

(6) Maximum instrumented range. Owing to hardware considerations, each radar system has a range beyond which detection is not possible. On the coverage display, all shading will be terminated at this maximum instrumented range independent of the range scale of the diagram. The maximum instrumented range will be indicated with a dashed vertical line on the loss display.

(7) Antenna type. There are five antenna types allowed within IREPS. These are Omni, Sin(X)/X, cosecant-squared, generic height-finder, and specific-system height-finder. The antenna type that is selected dictates the amount of power radiated at varying elevation angles and can seriously affect the coverage or loss display if wrongly selected.

The omni antenna is one that radiates uniformly in all directions. This type of antenna is normally employed with uhf communications systems where a whip antenna or a small aircraft-mounted antenna is used. It may also be used on any system that is known to radiate nearly uniformly in all directions.

The Sin(X)/X antenna is the most common type of directional antenna used by most surface-search and air-search radars.

The cosecant-squared antenna type is a special antenna used in some air-search and airborne radars. This type of antenna should only be selected if it is known to a certainty that it is appropriate.

The generic height-finder antenna type is used in three-dimensional radars. In this type of radar, a narrow-beam antenna is scanned vertically to determine target elevation angle and, therefore, height.

The specific system height-finder antenna is also used in three-dimensional radars. In addition to the scanning of a narrow beam in the vertical, the power of the radar is reduced at predetermined angles. If this type of antenna is selected, the operator must also provide the angles and power reduction factors associated with these angles.

(8) Antenna beamwidth. This is the vertical beamwidth and describes the angle between the half-power points in the antenna pattern. A Sin(X)/X antenna with a 4-degree vertical beamwidth will radiate only half as much power 2 degrees above and 2 degrees below the direction of maximum power radiated. Normal values of beamwidth for the Sin(X)/X antenna are from 1 to 30 degrees. For a height-finder, the value is normally on the order of 1 degree and describes the width of the beam being scanned and not the entire composite pattern. For the cosecant-squared antenna, the beamwidth describes the angle up to which the pattern behaves like an omni antenna and is usually a value of 2 degrees or less.

(9) Antenna elevation angle. For the Sin(X)/X, cosecant-squared and height-finder antenna types, the antenna elevation angle describes the direction of maximum power radiated by the antenna. This elevation angle is measured from the local horizontal (zero elevation angle) and increases in an upward direction. For most surface-based systems, this angle will be zero. For many airborne radars, this angle will be slightly downward (negative elevation angle). Except in special circumstances, the height-finder elevation angle will be zero.

4.3.2 Forward-Looking Infrared (FLIR) System Parameters

One of the most critical parameters employed in assessing the performance of a FLIR system is the minimum detectable temperature difference (MDTD). The MDTD is defined as the minimum difference in temperature between the target and its background needed by the FLIR system for detection. For use within IREPS, the MDTD is defined as:

$$MDTD\ (\gamma) = a_1 + a_2\gamma((1 + (2\ \gamma_x e_x)^2)^{.5}\ \ (1 + (2\ \gamma_y e_y)^2)^{.5}) \qquad (6)$$

where the coefficients a_1, a_2, e_x, and e_y are characteristic of the particular FLIR, and the parameter γ is the geometric mean of the horizontal (γ_x) and vertical (γ_y) target spatial wavelengths. These coefficients have no physical meaning and must be determined by experimentation. NOSC has determined coefficients for several specific FLIR systems. These parameters are available upon request by organizations meeting the security requirements associated with these systems. Use of the FLIR Performance Range Summary for systems other than those specified by NOSC is not recommended until such time as additional polynominal coefficients can be determined.

4.3.3 Display Parameters

The display parameters are for the convenience of the operator and have no influence upon the validity of the IREPS models used to make a performance assessment. These parameters are the following:

(1) Display option. The display option defines the maximum altitude and range for the coverage display, or the maximum range for the loss display when these products are requested. These options are illustrated in figure 4-21.

Option	Maximum Altitude	Maximum Range
A	50,000 ft	200 nmi
B	25,000 ft	100 nmi
C	10,000 ft	50 nmi
D	20,000 m	400 km
E	10,000 m	200 km
F	5,000 m	100 km
G	User-defined scales	
H	User-defined at runtime	

Figure 4-21. Coverage and loss-display options

Selection of option G allows the operator to specify the maximum range (up to 1000 nautical miles) and height (up to 100,000 feet) for the coverage display and the maximum range (up to 1000 nautical miles) for the loss display. In addition, metric and English units of measurement may be mixed or matched. Option H performs the same function as option G except the numerical values may be specified at the time of actual product

generation. The operator is cautioned about selection of options G and H. Scale distortion may result for improperly selected values, thus making the coverage display hard to interpret or misleading upon casual inspection.

(2) Security classification. The IREPS program will accept parameters from many different systems, some of which may be classified at differing security levels. As a convenience in labeling the IREPS products, a security classification appropriate to the system parameters must be entered. NOTE! This labeling convenience does not relieve the burden of security from the operator. It is the sole responsibility of the operator to handle any classified material in accordance with directives of higher authority.

(3) Labels. Two lines of labels, of up to 80 characters each, may be entered by the operator for each system. The labels may be used in any manner but it is a good idea to at least describe the system and to define what the free-space range value(s) was based upon.

5. REFRACTOMETER GUIDELINES

Commencing with the deployment of E2-C aircraft carrying the AN/AMH-3 Electronic Refractometer Set, also known as the airborne microwave refractometer (AMR), a new source of data has become available for determining electromagnetic propagation conditions in the operating area. The IREPS Refractometer option, described in section 4.2.1.7, accesses the data recorded by the refractometer and presents displays to the operator to assist in analyzing this data into profiles usable by the IREPS program. In most cases, the operator will find this analysis to be quite easy. In a few cases, the operator will be required to use good judgement and understanding of the atmosphere to reject bad data. The following sections discuss the hardware installation, diagnostic testing of the hardware, and analyzing the refractometer data.

5.1 HARDWARE INSTALLATION

On the HP520 computer implementation of the IREPS 3.0 software, two additional hardware items are needed to support the refractometer option. These are the Memodyne model M-80 digital cassette reader and the Hewlett-Packard model 27128 Asynchronous Serial Interface card. The M-80 reader accepts and reads a standard Phillips cassette tape that has data recorded by the AMR. This unit is interfaced to the HP520 computer by the HP 27128. If the hardware is not the same as the specifications of figures 5-1 and 5-2 (or is unknown), the following manuals may be needed to install the hardware:

(1) Memodyne model M-80 Instruction Manual
(2) Hewlett-Packard Asynchronous Serial Interface Technical Manual (pn 27132-90001).

With the HP520 computer powered off, open the right-hand side (facing the computer keyboard) to obtain access to the I/O module. There are four slots, numbered 2 through 5. Insert the 27128 card into any empty slot; keep track of the slot number into which this card is inserted. Attach one end of the I/O cable to the 27128 and the other end of the I/O cable to connector J1 on the M-80. Verify the 27128 switch settings (figure 5-2) before closing the I/O module access panels. Hardware installation is complete. Follow the diagnostic procedures to test the hardware connections.

Manufacturer:

Memodyne Corp.

Model: M80A2C1C

Description:

The reader unit is controlled by a microprocessor with initial state definitions stored in onboard ROM. The ROM code is factory programmed to the states described in the following table. The notation in this table is in Memodyne format.

ROM Code	Functional Description
9600	Baud rate
7 bits	word length
even	parity
1	stop bits
on	data terminal ready input
on	receiver from terminal
off	current loop receiver
on	receiver from modem
on	transmitter to terminal
on	current loop transmitter
on	transmitter to modem, RTS output
no	CTS input enables transmission
no	echo characters as received
disabled	aux clock
256 bytes	block size
one file	amount read for each read command
none	perform retries on read errors
no	read block parity bits
no	initialize format for each block
yes	insert spaces and cr-lf
yes	invert read data
no	transpose bits of each byte read
yes	transpose bytes of each word read
yes	convert read data to hex-ASCII
2 bytes	read bytes per format group
12 group	read format groups per line
no	execute user program
no	auto rewind and read on reset

Figure 5-1. Memodyne model M-80 configuration.

Manufacturer: Hewlett-Packard Co. Model: 27128A/B Description: The standard HP 27128A/B ASI Interface consists of: (1) the ASI card, (2) A 5-meter RS-232-C cable (female), and (3) Installation manual. "Switches:" Eight switches (SW1 through SW8) on the ASI card are used to configure the serial port. Switches SW1 through SW7 are closed (up position); Switch SW8 is open (down).

Figure 5-2. Hewlett-Packard ASI card.

5.2 REFRACTOMETER HARDWARE DIAGNOSTICS

Testing of the refractometer hardware operation should be performed immediately after the hardware is installed. A diagnostic program, REFRACPROG, is provided to isolate hardware problems. This program is exactly the same as the IREPS Refractometer Option program that reads the AMR data tape. When IREPS executes this program, it is run in a 'background' mode. In the 'background,' REFRACPROG does not fully trace its operation and does not require operator intervention; however, its error-reporting mechanisms are enabled. That is, the error-analysis section may be used for both the stand-alone mode and the IREPS execution mode to isolate hardware faults.

5.2.1 REFRACPROG Stand-Alone Execution

To load the diagnostic program for a complete tracing of possible hardware errors follow these steps:

(1) If the IREPS program is already installed on the internal hard disk, then go to step 2. Otherwise complete steps 1a through 1e.

   a. Place the master IREPS 3.0 disk #3 into the internal floppy drive of the computer.

   b. Type MSI"/:CS80,7,0", then press <Execute>.

   c. Type COPY "REFRACPROG:INTERNAL" TO "REFRACPROG" then press <Execute>.

   d. Remove the master IREPS 3.0 disk #3 and store it for safe keeping.

   e. Continue with step 3.

(2) Locate the directory that contains REFRACPROG and change to that directory using the MSI command.

(3) Type LOAD"REFRACPROG",1 then press <Execute>.

(4) The executing program clears the display then prompts

Enter the physical slot number of the I/O port:

Type the number of the slot (from section 5.1) then press <Return>. The program will trace and report any errors found. Refer to the following section for a discussion of error analysis.

5.2.2 REFRACPROG Error Analysis

Figure 5-3 shows the expected status report from the stand-alone execution of the REFRACPROG program during the actual transfer of data from the M-80 to the HP520. The first three lines of numerics are the M-80 communication and status bytes described in the M-80 Instruction manual and within the diagnostic program. The next line is a title label indicating that the diagnostic is operating in the stand alone mode. Lines begining with PASSED indicate successful completion of the various program steps required to establish communications and begin data transfer. Lines begining with SYNC ERROR indicate that data transfer is active and data are being transferred. The inverse-video line is a status message area used by both the IREPS and the stand-alone versions.

Errors are reported in the form

ERROR # brief error message ERRN=yyy secondary error message #

where

is replaced by a number from 0 to 10
yyy is replaced with a HP520 error number
yyy=0 implies no HP520 error applies

```
806 772
806 772
802 772

REFRACTOMETER PROGRAM: STAND ALONE TEST MODE

PASSED SETUP PHASE
PASSED INITIALIZATION PHASE
PASSED M-80 POWER ON/OFF PHASE
PASSED M-80 CIP CHECK, TSTATUS= 802
PASSED M-80 TAPE REWIND, TSTATUS= 802
PASSED M-80 LOAD FORWARD PHASE, TSTATUS= 802
PASSED ALL M-80 CHECKS, TSTATUS= 802
PASSED HP520 BUFFER ACTIVATION
SYNC ERROR, RESETING SCAN 48
SYNC ERROR, RESETING SCAN 54
SYNC ERROR, RESETING SCAN 387




                                      REFRACTOMETER TIME 00:17:27
```

Figure 5-3. Refractometer diagnostic display.

The following sections describe the error codes and possible fault causes:

(1) Error 0 or 1: The program has not been able to assign the output data file. Try deleting the file REFRAC and re-executing the diagnostic. Repeated failures indicate corrupt file structures or major problems with the HP520 computer.

(2) Error 2: Cannot configure the M-80 firmware. Probable causes are (1) broken or loose I/O cable, (2) Incorrect switch settings on the 411 card within the M-80, or (3) M-80 failure.

(3) Error 3: Cannot read M-80 status. Probable causes are (1) M-80 unit is not powered on, (2) broken or loose I/O cable, or (3) M-80 failure.

(4) Error 4: Status bits indicate no tape inserted into M-80. Probable causes are (1) No tape inserted, (2) bad M-80 Cassette-in-Place sensor, (3) broken or loose I/O cable, or (4) M-80 failure.

(5) Error 5: Tape rewind failure. Probable causes are (1) Bad M-80 Tape-in-motion bit, or (2) Bad M-80 BEOT sensor.

(6) Error 6: Tape load forward failure. Probable causes are (1) Bad M-80 BEOT sensor.

(7) Error 7: Tape load forward failure. Probable causes are (1) Bad Cassette-in-Place sensor, or (2) Bad M-80 Tape-in-Motion bit.

(8) Error 8: HP520 timer failure. Check operation of ON TIMEOUT, OUTPUTBIN, and ON CYCLE commands. Probable cause is HP520 failure.

(9) Error 9: HP520 read failure. Check operation of IOSTAT, ENTERBIN and TRANSFER commands. Probable cause is HP520 failure.

(10) Error 10: HP520 file cleanup failure. Probable causes are (1) files have been removed or (2) HP520 failure.

5.3 ANALYZING REFRACTOMETER REFRACTIVITY PROFILES

Refractivity data recorded by the AMR will not provide nice smooth profiles for a variety of reasons, including minor fluctuations of refactivity that actually occur in turbulent regions of the atmosphere; large fluctuations due to noise or erroneous measurements by the AMR because of water droplets in the AMR cavity; bit errors in reading the AMR tape; and apparent gradients due to horizontal changes in refractivity. Since subrefractive and trapping gradients are unbounded on one side, it is the analyst's concern to ensure that reasonable gradients are included in the analysis but that unreasonable gradients are excluded.

The normal operating mode of the E2-C is to launch, climb to station, carry out mission, descend, and recover. The AMR would record two profiles of refractivity during this flight, one on the ascent and one on the descent. Since the descent profile is the most recent, it is the one that the operator will generally select to analyze and use in the generation of IREPS products.

5.3.1 Approximating the Refractivity Profile

The objective of the refractometer refractivity-profile analysis is to approximate the shape of the profile using linear segments. Generally, a good approximation is obtained if a straight line drawn between neighboring user selected points differs from the actual refractivity profile by less than 4 to 6 N or M-units.

There are a number of real-world constraints that significantly impact the quality of the approximation. First, the accuracy of the AMR is plus or minus 2 N-units. Changes in refractivity of this magnitude are considered as noise and are physically meaningless. Second, the AMR measures the refractivity in a very small volume of air. If this small volume is not representative of the larger scale air mass, then the data is inappropriate for IREPS products. For example, on the ground prior to takeoff, the AMR sampling cavity may be exposed to hot exhaust gasses from an aircraft immediately before it on the runway. Obviously, the changes measured by the AMR are localized to airfield; these changes are not representative of the larger scale air mass surrounding the airfield and should not be included in the analysis. Third, bit errors caused by poor quality tape or dirty read/write tape heads may indicate very large changes in either height or refractivity. Typically, a bit error will show a very abrupt change followed by yet another abrupt change which returns to nearly the same plot position as before the bit error. Lastly, an IREPS profile is limited to a maximum of 29 height and refractivity pair entries. A typical AMR refractivity profile from the surface to an altitude of 20,000 feet may contain 500 samples; this profile must be sampled to fewer than 30 points before it can be inserted into the environmental library. This last constraint is not as severe as it appears. Experience

with analyzing most profiles is that the profile can be adequately described with between 10 to 15 entries of height and refractivity pairs.

It is strongly recommended that a new user gain experience with refractometer refractivity data analysis by trial. Pick the start and end times as the begining and ending of the refractometer data. This will request a height vs. refractivity analysis plot for the entire data set. Request a hard copy of the profile by placing the cursor into the DUMP GRAPH box and press <Return>. With a straight edge and a pencil, draw joining lines on the hard copy plot such that the maximum deviation from the straight line and the plotted data is less than 3 or 4 N-units. Using the CHANGE SCALE option may be useful to 'zoom' in for a detailed look at the data. Repeat the same steps using the cursor to sample the points found by the hand analysis and save this profile into the environmental library. Run the IREPS coverage product for both an airborne and surface system; use systems with display option A (section 4.3.3). Also run an AEW display product for heights of 50,000 feet and a scan range of 100 nmi. Repeat the entire procedure several times, but for each subsequent time reduce the number of points selected on the refractometer refractivity profile; allow greater refractivity deviations from the straight line. Compare the like-system coverage and AEW products to see the effects of over and under sampling the refractivity profile. This technique will aid in establishing subjective guidelines for approximating the refractivity profile.

5.3.2 Analysis Examples

A typical altitude-versus-time display resulting from such a flight is shown in Figure 5-4. The operator would select a beginning time near 4:04 and an ending time near 4:27 elapsed time. The corresponding refractivity profile is plotted in Figure 5-5 and the "+" symbols indicate the points the analyst has chosen to digitize the profile. Notice that small fluctuations in N, four N-units or less, are neglected. While these fluctuations are probably real, they represent transient features that are not significant on the scale of an IREPS coverage or loss diagram. By judiciously changing the scale of the refractivity plot, considerable detail can be observed and digitized. Scale changing is normally done several times to provide sufficient accuracy in digitizing.

Including small features does no harm to IREPS, but one can use up the 29 available levels very quickly in this manner. Additionally, the accuracy of the AMR is plus or minus two N-units, which makes selection of small refractivity structures undesirable.

On figure 5-5, note that the feature between 5000 and 6000 has been neglected. Had this feature been included, a strong trapping layer of -94 N/kft overlain by a strong subrefractive layer of 361 N/kft overlain by another strong trapping layer of -114 N/kft would have resulted. This would be equivalent to having a strong inversion overlain by a very moist layer overlain by another strong inversion, which is meteorologically unrealistic. The refractivity gradients are also unrealistically strong. Any subrefractive gradients greater than 100 N/kft should be considered suspicious. Any trapping layers less than -100 N/kft should also be considered doubtful.

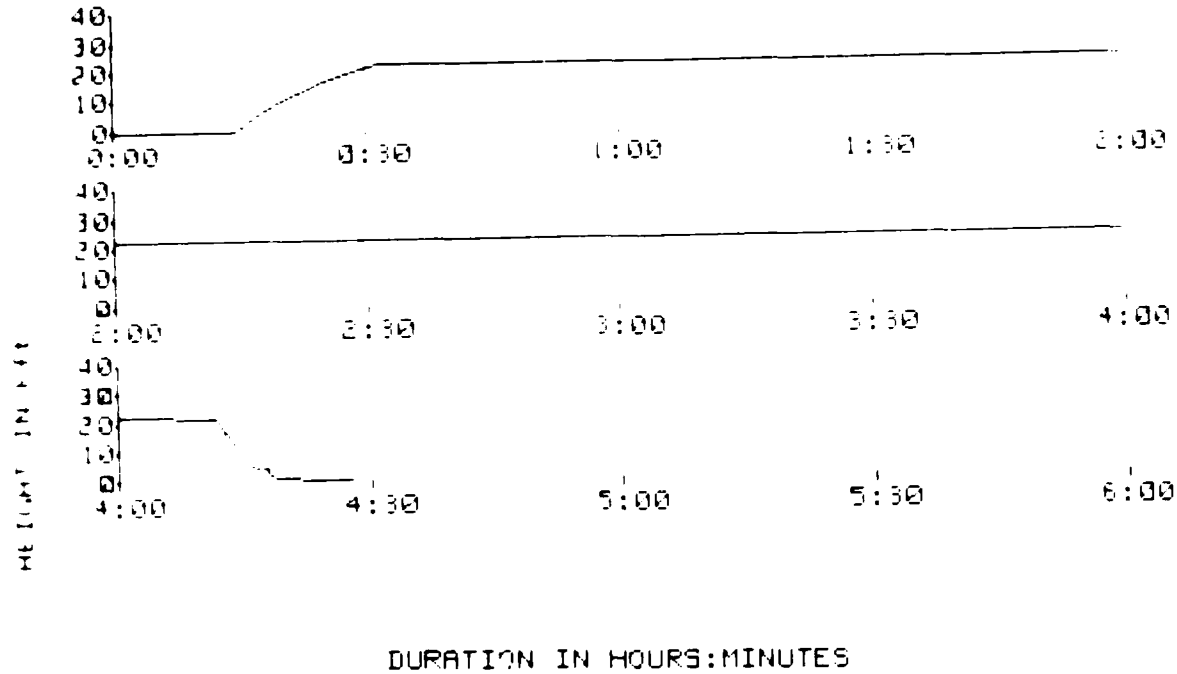


Figure 5-4. Refractometer altitude versus time display for a flight on 29 October 1984.

Additional information about the strengths of trapping layers in different ocean regions of the world is available in the IREPS historical summaries. For example, Figure 4-19 shows that the average trapping layer gradient in an elevated duct in the southern California area is -70 N/kft on a yearly basis.

If you are unsure of whether or not a particular feature should be included, include it, use the List Current Environmental-Data utility (4.2.4.3) to determine N gradients, and then the Edit User-Data Files utility (4.2.4.2) to delete unrealistic layers.

Another means to check on suspicious layers is to make comparisons with other profiles. Thus, the analyst should check the ascent profile from figure 5-4, which is shown in figure 5-6. Figure 5-6 has no indication of the feature between 5000 and 6000 feet and lends additional support to the decision to neglect those layers. The analyst can get a better feel for the changes that are taking place in refractivity by plotting both ascent and descent profiles together. To do this for figure 5-4, simply select a beginning time at zero and an ending time around 4:30. The result is shown in figure 5-7. It is apparent that the small features are indeed transient and that the gross features of the profile are consistent with the exception of the region between 3 and 7 kft. It is not apparent from the data alone what could be causing the discrepancy; possibly equipment problems, water droplets affecting the AMR, or erroneous data being read from the AMR tape.

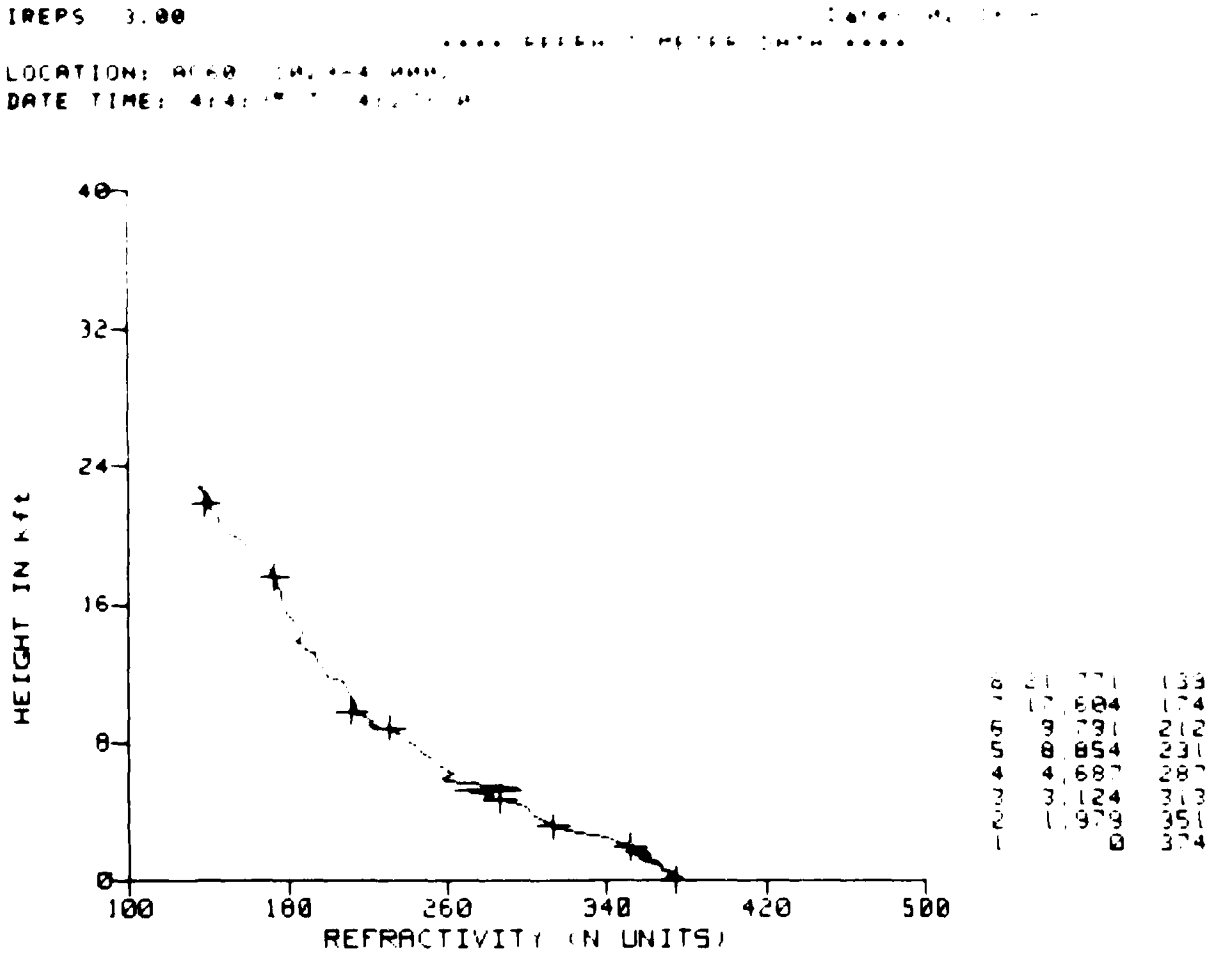


Figure 5-5. Refractometer refractivity profile for the time segment of 4:04:35 to 4:27:30 of figure 5-4.

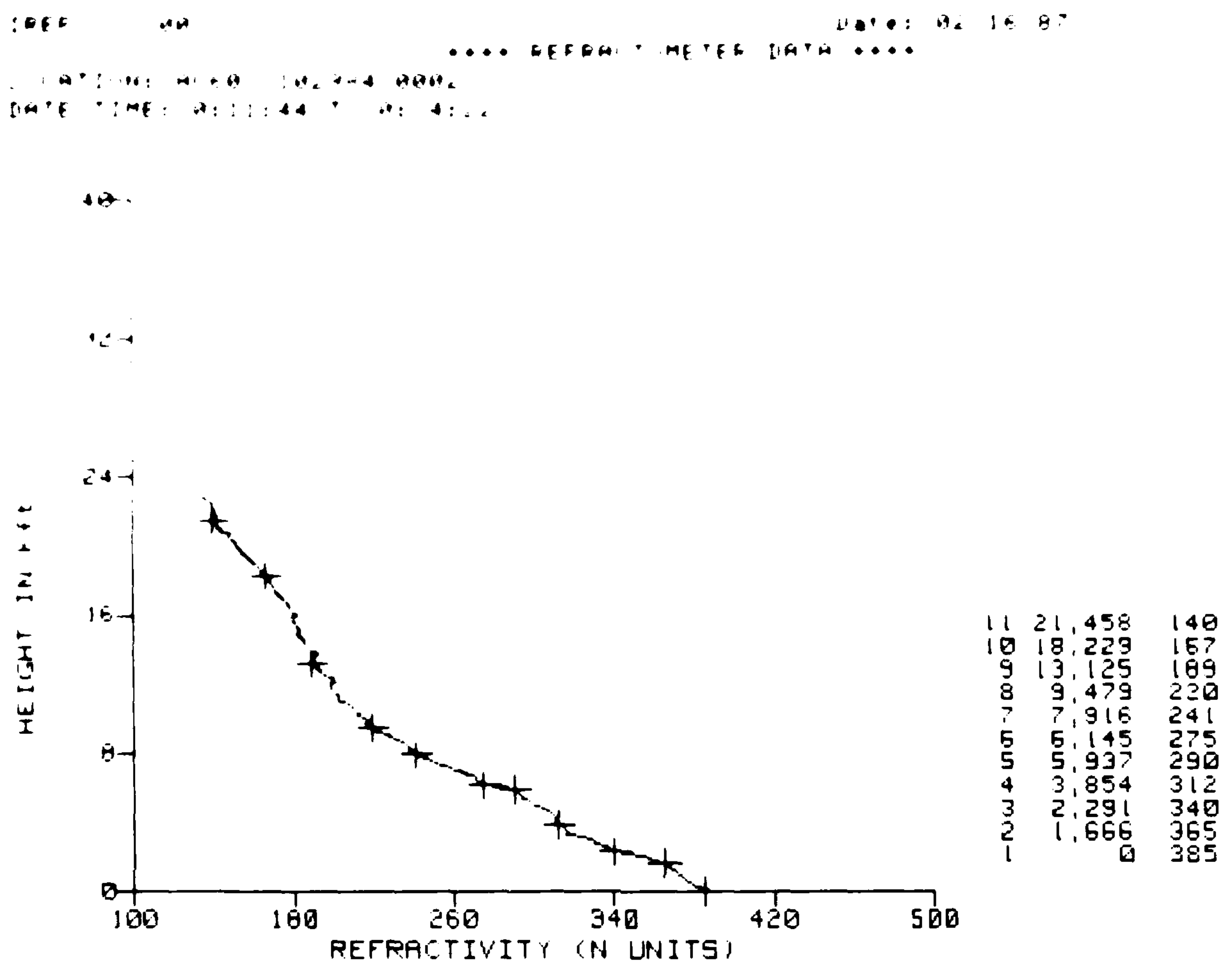


Figure 5-6. Ascent refractivity profile from figure 5-4.

IREPS 3.00 Date: 02/16/87

**** REFRACTOMETER DATA ****

LOCATION: AC603-102984-0002

DATE/TIME: 0:0:0 TO 4:29:47

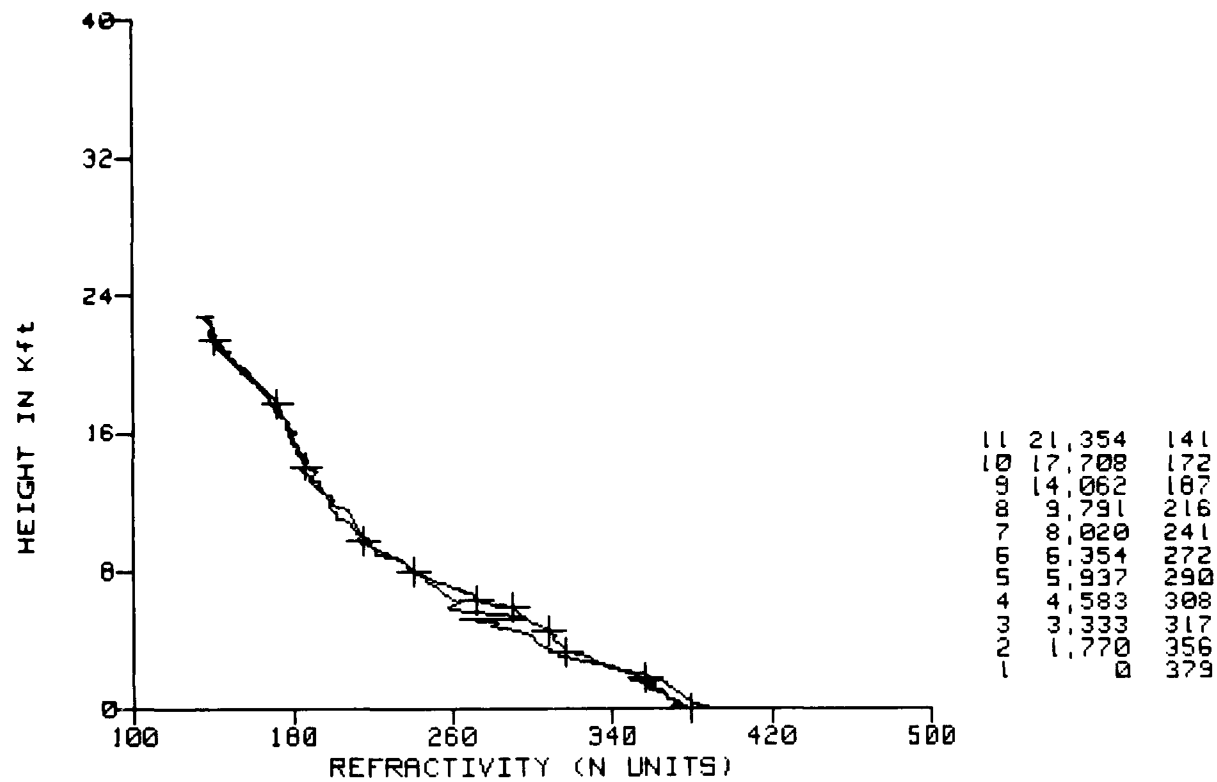


Figure 5-7. Combined ascent and descent refractivity profiles from figure 5-4.

In some cases, it may be desirable to analyze the refractivity profile in terms of the modified refractivity or M-units. The M-unit analysis greatly aids in picking out trapping layers or ducts. Normally, the M-unit profile is increasing. A trapping layer is readily observed when the M-unit decreases with height.

Analysis of a second flight provides additional insight. Figure 5-8 shows the height versus time display. Selecting an ascent profile from the 3:00:26 to 3:23:38 time frame yields the profile in Figure 5-9. The surface point was obtained by linearly extrapolating the lowest point on the profile (about 800 ft) to the surface. This profile shows a typical trapping layer which lies between levels 2 and 3 and has an N gradient of about -64 N/kft.

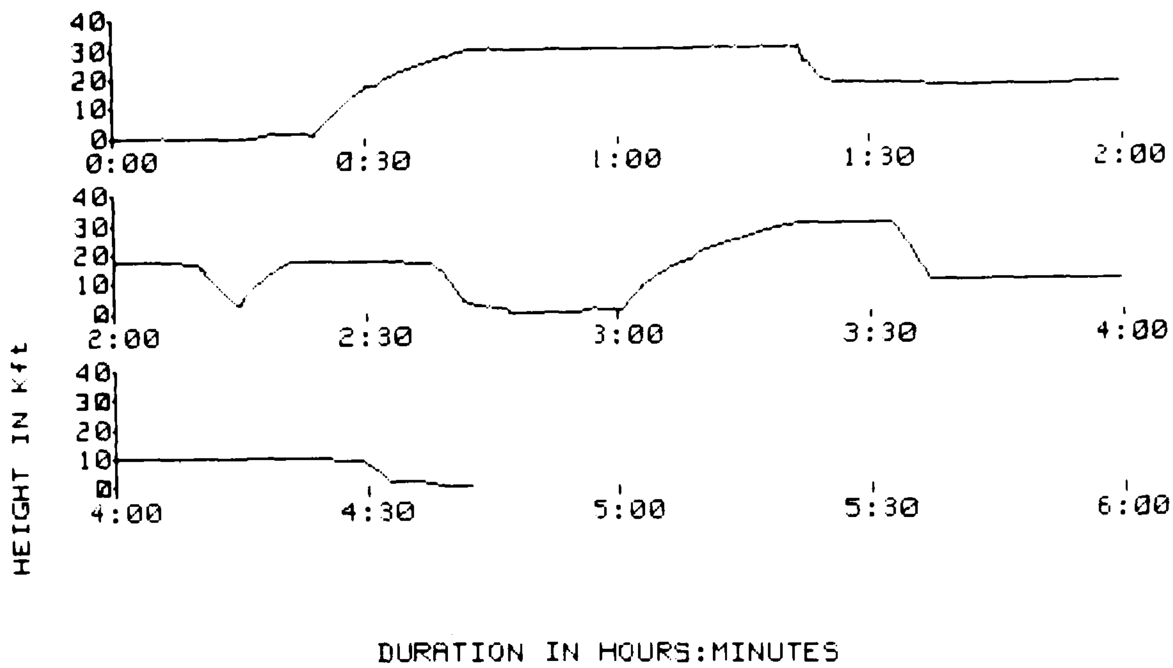
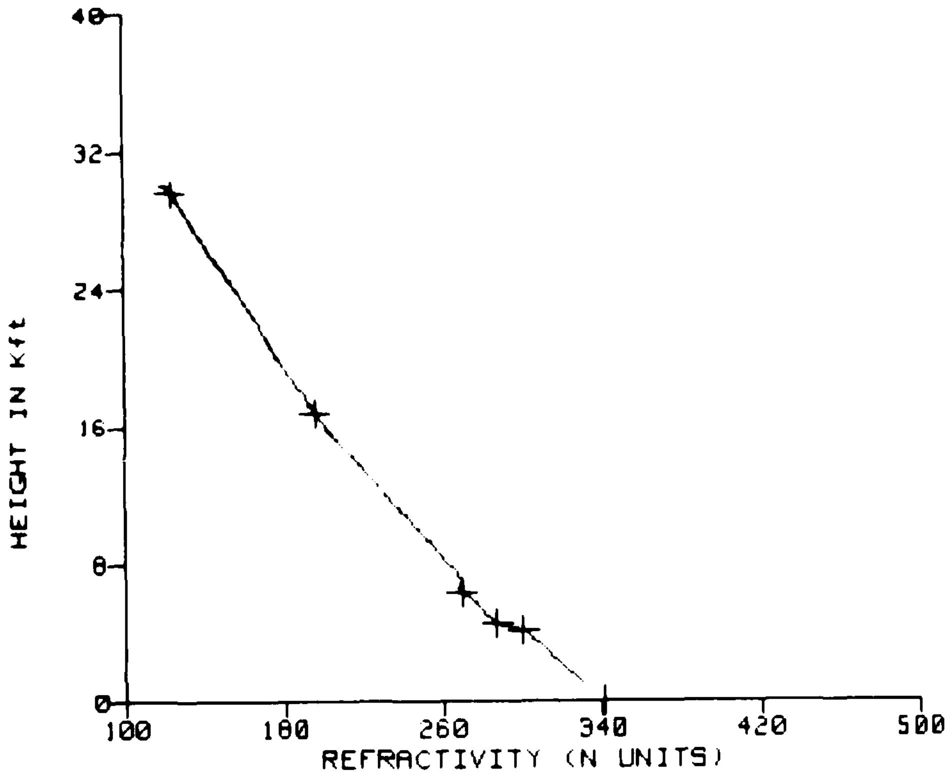


Figure 5-8. Refractometer altitude versus time display for flight on 8 February 1984.

IREPS 3.00 Date: 02 16 87

**** REFRACTOMETER DATA ****

LOCATION: AC085-020884-0004
DATE/TIME: 3:0:26 TO 3:23:38



6	29,584	124
5	16,771	196
4	6,354	269
3	4,583	287
2	4,166	300
1	0	341

Figure 5-9. Refractometer refractivity profile for times between 3:00:26 and 3:23:38 hours on 8 February 1984.

Selecting the final descent profile to be from 3:29:22 to 4:43:32 yields the profile in Figure 5-10. Interestingly, the trapping layer at 4 kft appears to have either weakened or lifted to 10 kft. However, the feature at 10 kft is suspicious in that it has a very sharp gradient. Looking again at Figure 5-8 shows that during the time frame that was selected, the aircraft descended to approximately 10 kft and maintained that altitude for about 55 minutes before continuing the descent. At typical aircraft speeds, this could easily represents a horizontal distance of 200 to 300 nmi. Over these distances, the horizontal gradient of refractivity could be 15 to 20 N-units thus introducing an offset into the profile. To compensate for this, the analyst adjusted the digitized points to the right of the actual profile above 10 kft. A meteorological analog to this situation would be in interpreting marine barograph traces, where the analysis of pressure changes must also include the movement of the barograph within the pressure field.

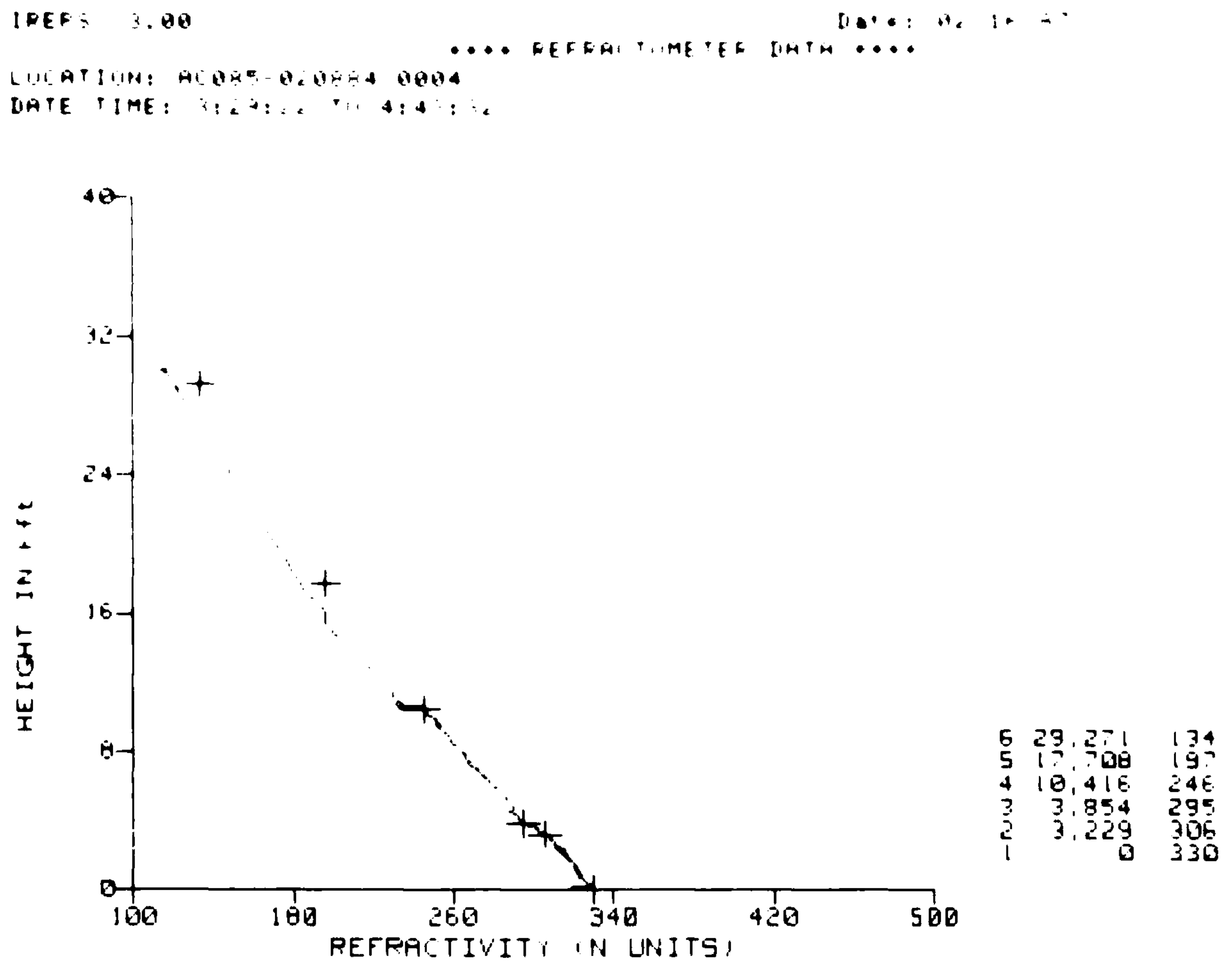


Figure 5-10. Refractometer refractivity profile for times between 3:29:22 and 4:43:32 hours on 8 February 1984.

6. GLOSSARY

AMR	Airborne Microwave Refractometer
BSCM	Basic Software Configuration Manual
EM	Electromagnetic
ESM	Electromagnetic Support Measures
FLIR	Forward-Looking Infrared
hf	High Frequency
IREPS	Integrated-Refractive-Effects Prediction System
MDTD	Minimum Detectable Temperature Difference
MHz	Megahertz
nmi	Nautical Miles
msl	mean sea level
OS	Operating System
RCS	Radar Cross Section
RSONDE	Radiosonde
uhf	Ultrahigh Frequency
XBT	Expendable Bathythermograph

APPENDIX A

IREPS 3.0 User's Manual Addendum

AMR Tape Format Description

11 May 1987

"TAPEFOR:BYER"

TAPE FORMAT INFORMATION FOR THE AN/AMH-3

THE FOLLOWING IS A DESCRIPTION OF THE TAPE FORMAT FOR RAW DATA RECORDED BY THE AN/AMH-3. THIS DOCUMENT IS TO BE REPLACED BY A DRAWING AT A LATER DATE.

DATA IS RECORDED IN FOUR WORD FILES. FILE GAPS ARE 22 BITS--2 BEFORE THE DATA AND 20 FOLLOWING. WORD GAPS ARE 3 BITS EACH. EACH 16 BIT WORD CONTAINS 3 4-BIT BCD DIGITS, 1 STATUS BIT, AND A 3 BIT IDENTIFIER CODE. BCD DIGITS ARE RECORDED WITH THE LEAST SIGNIFICANT BIT OF THE LEAST SIGNIFICANT DIGIT FIRST.

RECORD SPEED IS 100 CHARACTERS/SECOND. TAPE BIT DENSITY IS 615 BITS/INCH. FILE CYCLE TIME IS 1.7032 SECONDS FROM A GIVEN BIT TO THE SAME BIT IN THE FOLLOWING FILE.

TWO GROUPS OF DATA APPEAR ON THE TAPE. THE MAIN PROGRAM LISTED FIRST RECORDS THE RAW DATA. A TEST PROGRAM, WHICH APPEARS AT POWER TURN-ON, AND EVERY 29 MINUTES AFTERWARD, TO RECORD SYSTEM STATUS, IS LISTED SECOND.

BIT LISTING FOR THE MAIN PROGRAM

COMMENTS	BIT	FUNCTION
		2 BIT FILE GAP
	1	BIT 1
	2	BIT 2
		STATIC PRESSURE READING RECORDED
		LEAST SIGNIFICANT DIGIT
	3	1'S BIT
	4	2'S BIT
	5	4'S BIT
	6	8'S BIT
		MIDDLE DIGIT
	7	1'S BIT
	8	2'S BIT
	9	4'S BIT
	10	8'S BIT
		MOST SIGNIFICANT DIGIT
	11	1'S BIT
	12	2'S BIT
	13	4'S BIT
	14	8'S BIT
		SOURCE/STATUS DIGIT
	15	STATIC PRESSURE OVERRANGE BIT
CODE FOR STATIC PRESSURE	16	0
	17	0
	18	0

SHEET 2

BIT LISTING FOR THE MAIN PROGRAM

COMMENTS	BIT	FUNCTION
		WORD GAP
	19	BIT 1
	20	BIT 2
	21	BIT 3
		N COUNT READING RECORDED
		LEAST SIGNIFICANT DIGIT
	22	1'S BIT
	23	2'S BIT
	24	4'S BIT
	25	8'S BIT
		MIDDLE DIGIT
	26	1'S BIT
	27	2'S BIT
	28	4'S BIT
	29	8'S BIT
		MOST SIGNIFICANT DIGIT
	30	1'S BIT
	31	2'S BIT
	32	4'S BIT
	33	8'S BIT
		SOURCE/STATUS DIGIT
	34	LOCK INDICATION BIT
	35	0
CODE FOR N COUNT	36	1
	37	0
		WORD GAP
	38	BIT 1
	39	BIT 2
	40	BIT 3
		TEMPERATURE READING RECORDED
		LEAST SIGNIFICANT DIGIT
	41	1'S BIT
	42	2'S BIT
	43	4'S BIT
	44	8'S BIT
		MIDDLE DIGIT
	45	1'S BIT
	46	2'S BIT
	47	4'S BIT
	49	8'S BIT

SHEET 3

BIT LISTING FOR THE MAIN PROGRAM

COMMENTS	BIT	FUNCTION
		MOST SIGNIFICANT DIGIT
	49	1'S BIT
	50	2'S BIT
	51	4'S BIT
	52	8'S BIT
		SOURCE/STATUS DIGIT
	53	TEMPERATURE OVERRANGE BIT
CODE FOR TEMPERATURE	54	0
	55	0
	56	1
		WORD GAP
	57	BIT 1
	58	BIT 2
	59	BIT 3
		PITOT PRESSURE READING RECORDED
		LEAST SIGNIFICANT DIGIT
	60	1'S BIT
	61	2'S BIT
	62	4'S BIT
	63	8'S BIT
		MIDDLE DIGIT
	64	1'S BIT
	65	2'S BIT
	66	4'S BIT
	67	8'S BIT
		MOST SIGNIFICANT DIGIT
	68	1'S BIT
	69	2'S BIT
	70	4'S BIT
	71	8'S BIT
		SOURCE/STATUS DIGIT
	72	PITOT PRESSURE OVERRANGE BIT
CODE FOR PITOT PRESSURE	73	0
	74	1
	75	1
		FILE GAP (20 BITS)
	76	BIT 1
	77	BIT 2
	78	BIT 3
	79	BIT 4
	80	BIT 5
	81	BIT 6
	82	BIT 7

SHEET 4

BIT LISTING FOR THE MAIN PROGRAM

COMMENTS	BIT	FUNCTION
	83	BIT 8
	84	BIT 9
	85	BIT 10
	86	BIT 11
	87	BIT 12
	88	BIT 13
	89	BIT 14
	90	BIT 15
	91	BIT 16
	92	BIT 17
	93	BIT 18
	94	BIT 19
	95	BIT 20

END OF MAIN DATA FILE

BIT LISTING FOR THE TEST PROGRAM

****NOTE: SOURCE CODE BITS ON SOME UNITS ARE IN ERROR ****

COMMENTS	BIT	FUNCTION
		3 BIT FILE GAP
	1	BIT 1
	2	BIT 2
	3	BIT3
		LOW CALIBRATION READING RECORDED
		LEAST SIGNIFICANT DIGIT
	4	1'S BIT
	5	2'S BIT
	6	4'S BIT
	7	8'S BIT
		MIDDLE DIGIT
	8	1'S BIT
	9	2'S BIT
	10	4'S BIT
	11	8'S BIT
		MOST SIGNIFICANT DIGIT
	12	1'S BIT
	13	2'S BIT
	14	4'S BIT
	15	8'S BIT

SHEET 5

BIT LISTING FOR THE TEST PROGRAM

COMMENTS	BIT	FUNCTION
		SOURCE/STATUS DIGIT
	16	LOW CALIBRATION OVERRANGE BIT
CODE FOR LOW	17	1
CALIBRATION POINT	18	1
	19	1
		WORD GAP
	20	BIT 1
	21	BIT 2
	22	BIT 3
		HIGH CALIBRATION READING RECORDED
		LEAST SIGNIFICANT DIGIT
	23	1'S BIT
	24	2'S BIT
	25	4'S BIT
	26	8'S BIT
		MIDDLE DIGIT
	27	1'S BIT
	28	2'S BIT
	29	4'S BIT
	30	8'S BIT
		MOST SIGNIFICANT DIGIT
	31	1'S BIT
	32	2'S BIT
	33	4'S BIT
	34	8'S BIT
		SOURCE STATUS DIGIT
	35	HIGH CALIBRATION OVERRANGE BIT
	36	1
CODE FOR HIGH	37	0
CALIBRATION POINT	38	1
		WORD GAP
	39	BIT 1
	40	BIT 2
	41	BIT 3
		AFC VOLTAGE [illegible]
		LEAST SIGNIFICANT DIGIT
	42	1'S BIT
	43	2'S BIT
	44	4'S BIT
	45	8'S BIT

SHEET 6

BIT LISTING FOR TEST PROGRAM

COMMENTS	BIT	FUNCTION
		MIDDLE DIGIT
	46	1'S BIT
	47	2'S BIT
	48	4'S BIT
	49	8'S BIT
		MOST SIGNIFICANT DIGIT
	50	1'S BIT
	51	2'S BIT
	52	4'S BIT
	53	8'S BIT
		SOURCE/STATUS DIGIT
	54	AFC OVERRANGE BIT
CODE FOR	55	1
AFC VOLTAGE	56	0
	57	1
		WORD GAP
	58	BIT 1
	59	BIT 2
	60	BIT 3
		ID VOLTAGE READING RECORDED
		LEAST SIGNIFICANT DIGIT
	61	1'S BIT
	62	2'S BIT
	63	4'S BIT
	64	8'S BIT
		MIDDLE DIGIT
	65	1'S BIT
	66	2'S BIT
	67	4'S BIT
	68	8'S BIT
		MOST SIGNIFICANT DIGIT
	69	1'S BIT
	[illegible]	2'S BIT
	[illegible]	4'S BIT
	[illegible]	8'S BIT
		SOURCE STATUS DIGIT
	73	PITOT PRESSURE OVERRANGE BIT
[illegible]	74	1
[illegible]	[illegible]	1
	76	1

SHEET 7

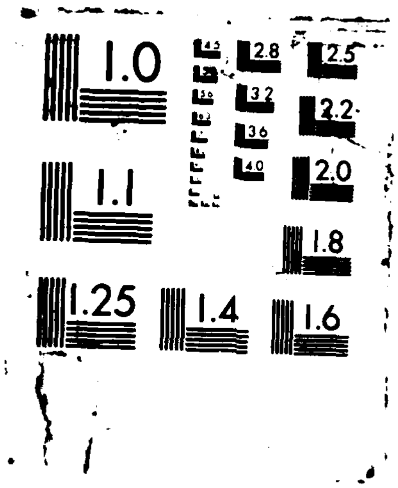
BIT LISTING FOR THE TEST PROGRAM

COMMENTS	BIT	FUNCTION
		FILE GAP (18 BITS
	77	BIT 1
	78	BIT 2
	79	BIT 3
	80	BIT 4
	81	BIT 5
	82	BIT 6
	83	BIT 7
	84	BIT 8
	85	BIT 9
	86	BIT 10
	87	BIT 11
	88	BIT 12
	89	BIT 13
	90	BIT 14
	91	BIT 15
	92	BIT 16
	93	BIT 17
	94	BIT 18

END OF TEST DATA FILE

AD-A190 390 IREPS (INTEGRATED REFRACTIVE EFFECTS PREDICTION SYSTEM) 2/2
3.0 (USER'S MANUAL)(U) NAVAL OCEAN SYSTEMS CENTER SAN
DIEGO CA W L PATTERSON ET AL. SEP 87 NOSC/TD-1151

UNCLASSIFIED F/G 20/14 NL


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

APPENDIX B

IREPS 3.0 User's Manual Addendum

Software Status Report

11 May 1987

IREPS SOFTWARE STATUS

ISSR: 0001 Date:05/11/87
Version: 3.01

Description:
IREPS 3.0 is upgraded to IREPS 3.01. A set of three floppy disks is provided containing all program files. User data files from 3.0 (Environment, Cover Systems, Loss Systems, etc) are directly compatible with the 3.01 version.

Users that currently have IREPS 3.0 should follow the update procedures described below.

Users that do not have IREPS 3.0 should follow the install procedures described below. Note that a fourth disk is provided that contains dummy data for the Environment, Cover Systems, etc. This data disk is unclassified.

Instructions for updating hard disk (IREPS 3.0 already installed):
Insert IREPS 3.01 Disk 1 into the floppy, type in
LOAD "INSTALL:INTERNAL",UPDATE
then press the <EXECUTE> key. Follow the instructions on the screen.

Instructions for installing IREPS 3.01 (IREPS 3.0 not on disk):
Insert IREPS 3.01 Disk 1 into the floppy, type in
LOAD "INSTALL:INTERNAL"
then press the <EXECUTE> key. Follow the instructions on the screen.

Instructions for removing IREPS 3.0/3.01 from hard disk:
Insert IREPS 3.0 or 3.01 Disk 1 into the floppy, type in
LOAD "INSTALL:INTERNAL",PURGE
then press the <EXECUTE> key. Follow the instructions on the screen.

Status: Update

ISSR: 0002 Date:05/11/87
Version: 3.01

Description:
Discussions with users of IREPS 3.0 indicate a need for a stand-alone routine to easily transfer the data files (Environment, Cover Systems, Loss Systems, etc) back and forth between the hard disk and the floppy disk. The DATA.BACKUP program is now provided to easily archive and load the IREPS data files. DATA.BACKUP is menu driven and self-explanatory. It is located in the /IREPS_3.0 directory when the update from 3.00 to 3.01 is completed or IREPS 3.01 is installed.

Status: Update

ISSR: 0003 Date:05/11/87
Version: 3.01

Description:
In 3.00, there is no convenient manner to display the raw AMR tape data for checking status conditions. The update to 3.01 provides a stand-alone routine named REFRACTEST which accomplishes this task. REFRACTEST will be located in the /IREPS_3.0 directory and executes in a manner similiar to the stand-alone refractometer diagnostic described in the IREPS User's Manual. In addition, a description of the tape format is provided as an addendum to the User's Manual.

Status: Update

ISSR: 0004 Date:05/11/87
Version: 3.00,3.01

Description:
The INSTALL program found on IREPS 3.0x Disk 1 is used to copy the program files and data files from the master floppy disks to a hard disk. This program makes the assumption that IREPS does NOT exist on the hard disk before the installation process begins. If any IREPS files exist on the hard disk, INSTALL complains and stops. To remove all IREPS files from the hard disk, place the IREPS 3.0x Disk 1 in the floppy drive, then type in:

LOAD "INSTALL:INTERNAL",PURGE
then press the <Execute> key.

Warning! This sequence will remove all IREPS files including the data files. If you have data files on the hard disk that you want to reload, use the DATA.BACKUP provided with the 3.01 update.

Status: Information.

ISSR: 0005 Date:05/11/87
Version: 3.00,3.01

Description:
Refractometer software will now support the HP 27130A/B multiplexer in addition to the HP 27128A/B ASI described in the IREPS 3.0 User's Manual. The device specifier in the configuration option is:

device specifier = 100*slot + connector#.

The wiring between the MUX and the M-80 tape reader is:

MUX Pin	M-80 J1
2	2
3	3
7	7

Status: Information

ISSR: 0006 Date:05/11/87
Version: 3.00,3.01

Description:
An external printer may be used in place of the built in thermal printer. The printer specifier in the configuration option is:

printer specifier = 100*slot + address

Status: Information

ISSR: 0007 Date:05/11/87
Version: 3.00,3.01

Description:
The default directory paths in the configuration option are:

Subroutines:	/IREPS_3.0
User data files:	/IREPS_3.0/USERDATA
Historical files:	/IREPS_3.0/HISTDATA
Refractometer data:	/IREPS_3.0/REFDATA

Non-standard path names may cause failure of the updating routines. It is strongly recommended that the default path names be used.

Status: Information

ISSR: 0008 Date:05/11/87
Version: 3.00,3.01

Description:
ESM is capable of handling cross-polarized transmitter and receiver systems. LOSS is not capable of handling cross-polarized transmitter and receiver systems. Comparisons between LOSS and ESM products for cross-polarized systems may show as much as 15 dB difference.

Status: Information

ISSR: 0009 Date:05/11/87
Version: 3.00,3.01

Description:
Propagation models do not account for beam overlap of the SPY-1 radar.

Status: Under investigation

ISSR: 0010 Date:05/11/87
Version: 3.00,3.01

Description:
Surface search always includes a fixed molecular attenuation rate for all frequencies. The attenuation rates are:

0.012 dB/km for frequencies < 6 GHz,
0.015 dB/km for frequencies > 6 GHz.

Detection range may be underestimated for a low frequency (< ~3 GHz) radar against the largest targets.

Status: Under investigation.

ISSR: 0011 Date:05/11/87
Version: 3.00

Description:
No end option in RFSDR. Must use the backup key to exit routine.

Status: Fixed in 3.01.

ISSR: 0012 Date:05/11/87
Version: 3.00

Description:
AEW observed to generate an error message indicating a square root of a negative number. Problem is in the calculation of alpha prime. Also, AEW observed to fail when the environment is an elevated duct above a surface-based duct.

Status: Fixed in 3.01

ISSR: 0013 Date:05/11/87
Version: 3.00

Description:
Refractometer initialization sequence exhibits failures if the M-80 is not powered on at the start of the process.

Status: Fixed in 3.01

ISSR: 0014 Date:05/11/87
Version: 3.00

Description:
Refractometer option has been observed to create a data file of greater than 4 Mbytes. This has been isolated to a problem in the HP BASIC OS. It has been temporarily patched by creating the output data file to 204 blocks and never writing past the eof.
Warning! Refractometer data files on hard disk (/IREPS_3.0/REFDATA/REFRAC) or refractometer data files created under IREPS 3.00 may not be 204 blocks in length. Use of these files under 3.01 may still exhibit the exact same problem. If this problem of creating a very large refractometer data file occurs, manually remove the disk file by typing in:

PURGE "/IREPS_3.0/REFDATA/REFRAC"
then press <Execute>

Status: Fixed in 3.01

ISSR: 0015 Date:05/11/87
Version: 3.00

Description:
Refractometer currently handles 5.17 hours of data from the AMR. At least one data tape has been observed with ~10 hours of data. IREPS 3.01 will now handle 10 hours of data per tape.

Status: Fixed in 3.01

ISSR: 0016 Date:05/11/87
Version: 3.00

Description:
Combinations of backup key entries could confuse the refractometer option, leading to an erroneous current environment. In 3.01, the refractometer option will now never load the current environment (a digitized profile is always placed in the environment library). To recover a digitized profile, you must now go through the Inputs Option and select the current environment from the library.

Status: Fixed in 3.01

ISSR: 0017 Date:05/11/87
Version: 3.00

Description:
Negative static pressures (tape bit errors) can cause the calculated height to go negative in the refractometer option. To circumvent this problem, 3.00 would locate the minimum height and subtract this value from each element in the height array, forcing the adjusted minimum height to 0. This technique proved difficult for the operator to recognize and has been deleted in 3.01. Negative heights are not plotted.

Status: Fixed in 3.01

ISSR: 0018 Date:05/11/87
Version: 3.00

Description:
An internal date was erronously printed on all IREPS products. This date is used only by NOSC to track the revision numbering.

Status: Fixed in 3.01

ISSR: 0019 Date:05/11/87
Version: 3.00

Description:
Wrong system names appear in FLIR and Surface Search edit.

Status: Fixed in 3.01

ISSR: 0020 Date:05/11/87
Version: 3.00

Description:
Transmitter power units (dBW) not displayed in ESM Emitter Edit.

Status: Fixed in 3.01

END
DATE
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